Pacific Islands Vulnerability Assessment
Coral Reef Species Narrative

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The Pacific Islands Fisheries Science Center conducted a climate change vulnerability assessment for six species groups in the Pacific Islands region (Giddens et al. unpublished). This data report summarizes the following assessments of each species in the coral reef species group: overall climate vulnerability rank (certainty determined by bootstrap following Hare et al. 2016), climate exposure, biological sensitivity, distributional vulnerability rank, data quality, climate effects on abundance and distribution, and life history (see Morrison et al. 2015 for further details).

Biological sensitivity and climate exposure were evaluated and scored by experts for each species. Biological sensitivity is representative of a species' capacity to respond to environmental changes in reference to a biological attribute. The Coral Reef Species Narrative is accompanied by the Coral Reef Species Profile, which provides further information on each biological sensitivity attribute for each species. The Coral Reef Species Profile was used to help experts evaluate biological sensitivity. Experts were also encouraged to use their own expertise and knowledge when evaluating. Climate exposure is defined as the degree to which a species may experience a detrimental change in a physical variable as a result of climate change. The inclusion of climate exposure variables followed four guidelines: 1) the variables are deemed to be ecologically meaningful for the species and geography in question, 2) the variables should be available on the NOAA ESRL Climate Change Data Portal for consistency across different CVAs, 3) the variables are available in the temporal and spatial domains suitable for inclusion,

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and 4) the quality of the modeled product was judged to be adequate for inclusion. By following these guidelines, the exposure scoring was a quantitative exercise as future values could be compared to historical values while incorporating observed patterns of natural variability. This allowed determination of likely severity of future changes in exposure on a species and area specific basis for each exposure variable. Scoring for biological sensitivity and climate exposure is based on scale from 1–4 (Low, Moderate, High, Very High) and scoring for data quality is ranked from 0–3 (No Data, Expert Judgement, Limited Data, Adequate Data). A high score for biological sensitivity and climate exposure indicates greater vulnerability. Expert Score Plots show the variation in expert scoring (5 experts per species). Scoring was completed in 2018. The mean score for each sensitivity attribute or exposure variable was calculated and a logic model was used to determine the component score for biological sensitivity and climate exposure. For example, if there are three or more attributes with a mean greater than or equal to, the sensitivity or exposure component score would be a 4 (Very High). Please see [Morrison et al. 2015] for remaining logic model's criteria. Overall climate vulnerability was determined by multiplying sensitivity and exposure component scores; the possible range of these scores was between 1 and 16. The numerical values for the climate vulnerability rank were the following: 1–3 (Low), 4–6 (Moderate), 8–9 (High), and 12–16 (Very High).

Hare JA, Morrison WE, Nelson MW, Stachura MM, Teeters EJ, Griffis RB, et al. 2016. A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf. PLoS One. 11: e0146756.

Morrison et al. 2015. Methodology for Assessing the Vulnerability of Marine Fish and Shellfish Species to a Changing Climate. U.S. Dept. of Commer, NOAA. NOAA Technical Memorandum NMFS-OSF-3, 48 p.

Contents

Green damselfish - *Abudefduf abdominalis*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate
Climate Exposure = Very High
Data Quality = 82% of scores ≥ 2

	Abudefduf abdominalis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.6	3	
	Prey Specificity	1.3	3	
	Adult Mobility	2.6	3	
	Dispersal of Early Life Stages	2.4	2.4	
	Early Life History Survival and Settlement Requirements	2.3	1.8	
	Complexity in Reproductive Strategy	1.9	2.2	
	Spawning Cycle	1.6	1.8	
	Sensitivity to Temperature	2.8	2.8	
	Sensitivity to Ocean Acidification	2.5	2.4	
	Population Growth Rate	1.2	1.4	
	Stock Size/Status	2	1.6	
	Other Stressors	2.4	1.6	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1	3	
	Current NS	1	3	
	Current Speed	1	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1	3	
	Surface Oxygen	4	3	
	Surface Salinity	1	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Green Damselfish (*Abudefduf abdominalis*)

Overall Climate Vulnerability Rank: **[High].** (98% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.6), Adult Mobility (2.6), and Sensitivity to Temperature (2.8).

Distributional Vulnerability Rank: **[Moderate].** All four attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, relatively high habitat specialization, and sensitivity to temperature. This species is associated with coral reefs, which are vulnerable habitats.

Data Quality: 82% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of green damselfish. This species is not highly dependent on one type of food as it feeds on a variety of algae and zooplankton. This species may be dependent upon coral reefs for habitat, especially during their juvenile life stage.

Life History Synopsis**:**

Green damselfish, endemic to Hawaiʻi, are found in depths ranging from 1–50 m [1]. This is a reef-associated species, found in quiet waters with rocky bottoms at inshore and offshore reefs. Seasonality in reproduction has not been reported for this species. Congeners are benthic spawners; several females deposit hundreds to thousandsof eggs that are gurded by males. *Abudefduf abdominalis* and *A. vaigiensis* form heterospecific social groups and mating pairs [2,3]. These and other species may depend on off-shore eddies to return fish larvae to the reef. Though not reported specifically for this species, coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [4]. Larvae of this species were found in a cold core eddy off of Kona, Hawaiʻi, which returns driting larvae to the reef. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km, and cross-channel dispersal can be common [5,6]. Pelagic larval duration is estimated at approximately 22 days for similar species (*A. viagiensis*). Eggs are demersal and adhere to the substrate, and males guard and aerate the eggs [2,7]. Field studies indicated that the distribution of juveniles in shallow water did not overlap with adult fish [1,8]. This species feeds on a variety of algae and zooplankton. This species is not highly mobile; others in the same genus have a home range size of less than 0.2 km [1,9]. They are limited in mobility as they defend the territories with which they are strongly associated [9]. There is a possibility of genetic swamping of this endemic species. A recent arrival of the widely distributed Indo-Pacific sergeant (*A. vaigiensis*) is hybridizing with *A. abdominalis* [10]. In Hawaiʻi, hybridization is significantly higher in the southeast archipelago (19.8%), compared to 5.9% in the northwest archipelago. Regions with similar densities of the two species had the greatest hybridization [10].

References

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Achilles tang - *Acanthurus achilles*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate
Climate Exposure = Very High
Data Quality = 71% of scores ≥ 2

	Acanthurus achilles	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.3	2.6	
	Prey Specificity	1.3	2.6	
	Adult Mobility	2.4	2.4	
	Dispersal of Early Life Stages	1.8	1.4	
	Early Life History Survival and Settlement Requirements	2.6	0.9	
	Complexity in Reproductive Strategy	1.4	1.8	
	Spawning Cycle	1.9	1.2	
	Sensitivity to Temperature	1.6	2.2	
	Sensitivity to Ocean Acidification	2.1	1.6	
	Population Growth Rate	1.7	1.4	
	Stock Size/Status	2.5	1.3	
	Other Stressors	1.7	1.8	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.7	3	
	Bottom Temperature	2.1	3	
	Current EW	1.2	3	
	Current NS	1.1	3	
	Current Speed	1.1	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.1	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.2	3	
	Surface Oxygen	3.9	3	
	Surface Salinity	1.5	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Achilles Tang (*Acanthurus Achilles*)

Overall Climate Vulnerability Rank: **[High].** (51% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Early Life History and Settlement Requirements (2.5) and Stock Size/status (2.5).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization.

Data Quality: 71% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

No studies have explicitly tested the effects of climate factors on the abundance or distribution of achilles tang.

Life History Synopsis**:**

Achilles tang are found in shallow water, generally less than about 5 m, along rocky shores or coral reefs exposed to wave action. Achilles tang feed primarily on turf algal species [1, 2]. No information is available on longevity or spawning behavior.

References

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Eyestripe surgeonfish - *Acanthurus dussumieri*

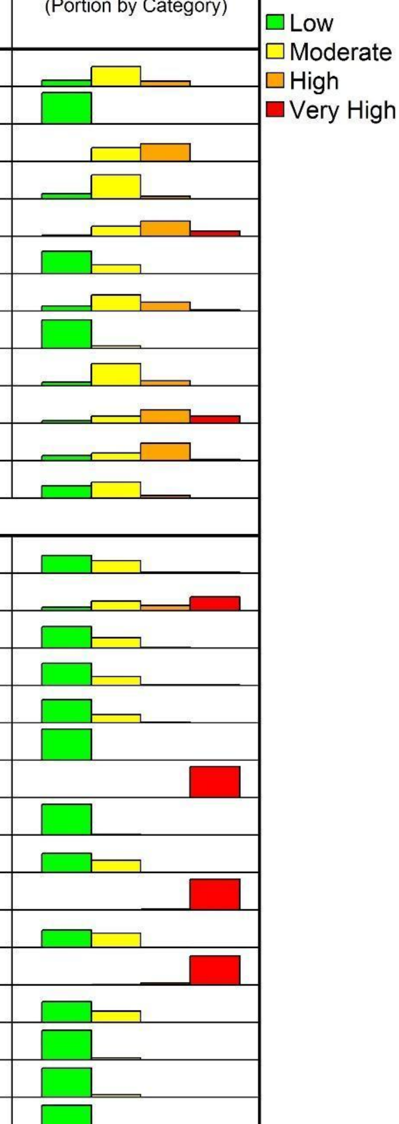
Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 79% of scores ≥ 2

	Acanthurus dussumieri	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.6	
	Prey Specificity	1	2.4	
	Adult Mobility	2.6	2.4	
	Dispersal of Early Life Stages	1.9	1.6	
	Early Life History Survival and Settlement Requirements	2.8	1.1	
	Complexity in Reproductive Strategy	1.3	2.2	
	Spawning Cycle	2.2	1	
	Sensitivity to Temperature	1.1	2.8	
	Sensitivity to Ocean Acidification	2	2	
	Population Growth Rate	2.8	1.8	
	Stock Size/Status	2.5	1.6	
	Other Stressors	1.7	1.6	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.3	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		



Eyestripe Surgeonfish (*Acanthurus dussumieri*)

Overall Climate Vulnerability Rank: **[High].** (97% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Early Life History and Settlement Requirements (2.8) and Population Growth Rate (2.8).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Eyestripe surgeonfish are found along the eastern coast of Africa, the southern Arabian Peninsula, southern Japan, New South Wales, Australia, New Caledonia, Guam, and Hawaiʻi (40° N to 37° S, 17° E to 155° W) [1]. No studies have explicitly tested the effects of climate factors on the abundance or distribution of eyestripe surgeonfish. However, as a coral reef species, they may be affected by coral degradation, especially at the juvenile stage [1].

Life History Synopsis**:**

Eyestripe surgeonfish are widespread roving fishes [2] found in a range of habitats, including waters to at least 130 m depth [3,4]. Adults are not highly mobile and stay within 1 km of their home range [5]. Juveniles are found on algal covered rocky reefs. They primarily feed on the film of fine green and blue-green algae, diatoms, and detritus covering sand, but also consume other algae [2,6-8]. Their life span is at least 28 years [9]. Maximum size is 54 cm [2], and size at maturity is 28 cm [9]. They are described as pair-spawners [10]. The von Bertalanffy growth coefficient and natural mortality were reported as 0.3 per year and 0.11 per year, respectively [11].

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Epaulette surgeonfish - *Acanthurus nigricauda*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 71% of scores $\geq$ 2

	Acanthurus nigricauda	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.6	2.2	
	Prey Specificity	1.2	2.2	
	Adult Mobility	2.5	1.8	
	Dispersal of Early Life Stages	2.1	1.4	
	Early Life History Survival and Settlement Requirements	2.3	0.9	
	Complexity in Reproductive Strategy	2	1.8	
	Spawning Cycle	2	1.2	
	Sensitivity to Temperature	1.6	2.2	
	Sensitivity to Ocean Acidification	1.7	2	
	Population Growth Rate	1.5	1	
	Stock Size/Status	2.4	1	
	Other Stressors	1.9	1	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Epaulette Surgeonfish (*Acanthurus nigricauda*)

Overall Climate Vulnerability Rank: **[Moderate].** (57% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.5) and Stock Size/Status (2.4).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 71% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of the epaulette surgeonfish. However, approximately 80% of surgeonfishes occurring exclusively in coral reef habitat are experiencing a greater than 30% loss of coral reef area [1,2].

Life History Synopsis**:**

Acanthurus nigricauda are widespread in the Indo-Pacific and found from East Africa to the Society Islands and Tuamotu Archipelago, northwards to Ryukyu Islands, Japan, and southwards to the Great Barrier Reef, Australia, and New Caledonia to 30 m depth [1]. *A. nigricauda* reportedly formed spawning aggregations on the Great Barrier Reef [1]. It may rely on eddies to retain larvae near settling grounds [3,4]. Though not reported specifically for this species, coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [5]. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations [6]. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km, and cross-channel dispersal can be common [7]. *Acanthurus nigricauda* inhabit sandy areas near coral reefs or rocky bottom [1]. This species grazes on the biofilm on sandy surfaces, and its diet consists of organic detritus and calcareous sediments with slight amounts of identifiable algae [1,8]. This species is not highly mobile. Home range size is less than 0.1 km for similar species in the same family [6]. Though not reported for this species, other acanthurids are known to aggressively maintain territories [9]. In Guam, abundance was estimated to be 1 ind/500 m^2 (2010). Additionally, this species comprises 2% of the acanthurid community and 5% of the acanthurid fishery in Guam. They are uncommon to rare in fished areas and uncommon in the American Samoa National Park [1]. Habitat preference varies among surgeonfishes. Some inhabit coral reefs for most of their life stages and others inhabit seagrass beds, mangroves, algal beds, or rocky reefs. Approximately 80% of surgeonfishes occurring exclusively in coral reef habitat are experiencing a greater than 30% loss of coral reef area and degradation of coral reef habitat quality across their distributions [1,2].

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Convict tang - *Acanthurus triostegus sandvicensis*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low

Climate Exposure = Very High

Data Quality = 93% of scores ≥ 2

	Acanthurus triostegus sandvicensis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.8	
	Prey Specificity	1.4	2.6	
	Adult Mobility	2.6	2.6	
	Dispersal of Early Life Stages	1.7	2	
	Early Life History Survival and Settlement Requirements	2.1	1.8	
	Complexity in Reproductive Strategy	1.5	2.2	
	Spawning Cycle	1.8	2.8	
	Sensitivity to Temperature	1.5	2.8	
	Sensitivity to Ocean Acidification	1.9	2.6	
	Population Growth Rate	1.4	2.4	
	Stock Size/Status	1.6	2.8	
	Other Stressors	1.6	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Convict Tang (*Acanthurus triostegus sandvicensis*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.6) and Early Life History and Settlement Requirements (2.1).

Distributional Vulnerability Rank: **[Very High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 93% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

No study has explicitly considered the potential impacts of climate change on convict tang, but this species appears not to be heavily dependent on corals and has been shown to increase in abundance following coral mortality events [1].

Life History Synopsis**:**

This species is found in rock, coral, rubble, or sand habitats to depths of at least 46 m, and possibly to 90 m [2] but are most abundant in shallow water often in habitats with low coral cover [3]. Juvenile and adult convict tang feed on a variety of benthic algae including filamentous algae [4-6] as well as some palatable macroalgae [7]. The largest specimen observed was 27 cm, but the species rarely exceed 20 cm [8]. Prime settlement habitats are very shallow (less than 1 m) rubble [9] and tide-pools [6]. They spawn all year in equatorial waters and in Hawaiʻi from February to March [10] and have been observed to form large spawning aggregations [11]. Individuals may migrate at least 2 km to the seaward side of a reef or the channels between lagoons to the open ocean to spawn [11].

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Bumphead parrotfish - *Bolbometopon muricatum*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 93% of scores ≥ 2

	Bolbometopon muricatum	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	3	2.8	
	Prey Specificity	2.2	2.8	
	Adult Mobility	2.4	2.4	
	Dispersal of Early Life Stages	1.9	2.2	
	Early Life History Survival and Settlement Requirements	3	1.8	
	Complexity in Reproductive Strategy	2.4	2.4	
	Spawning Cycle	1.7	2	
	Sensitivity to Temperature	1.6	2.8	
	Sensitivity to Ocean Acidification	2.5	2.2	
	Population Growth Rate	2.8	2	
	Stock Size/Status	2.8	2.6	
	Other Stressors	2	1.8	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Legend: Low, Moderate, High, Very High

Bumphead Parrotfish (*Bolbometopon muricatum*)

<u>Overall Climate Vulnerability Rank</u>: **[High].** (54% certainty from bootstrap analysis).

<u>Climate Exposure</u>: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

<u>Biological Sensitivity</u>: **[Moderate]**. Two sensitivity attributes scored a 3.0. These were Habitat Specificity and Early Life History and Settlement Requirements.

<u>Distributional Vulnerability Rank</u>: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

<u>Data Quality</u>: 93% of the data quality scores were 2 or greater.

<u>Climate Effects on Abundance and Distribution</u>:

Bolbometopon muricatum are found in the Red Sea, east to the Line Islands and Tuamotu Archipelago (French Polynesia), north to Taiwan, the Yaeyama Islands (Japan), and Wake Island (United States Minor Outlying Islands), south to northwest of Australia, the Great Barrier Reef, and New Caledonia [1-2]. Bumphead parrotfish occur in 13 Spalding et al. [3] provinces. They are typically found in exposed reef crest and shallow waters in depths between 1 to 30 m [4]. Bumphead parrotfish have a larger migratory range (less than 10 km) than other parrotfishes [5,6]. Their mobility is moderately constrained by behavior and habitat availability since they occur in groups and on coral reefs or lagoons [4,7,8].

B. muricatum were historically abundant across their range [9]. However, they are now considered rare, globally. At certain Indo-Pacific locations, local densities have been negatively correlated with fishing pressure. It is thought that some local populations have gone extinct. This species was uncommon around the U.S. Pacific Islands. They were observed only at 1 or 2 islands of a region (e.g., U.S. Line Islands, U.S. Phoenix Islands, Marianas Archipelago, or American Samoan Islands). A 2011 review reported that bumphead parrotfish were most abundant at Wake Atoll (~300 fish per km^2), followed by Palmyra Atoll (5.22 fish per km^2), Pagan Island in the Commonwealth of the Northern Mariana Islands (1.62 fish per km^2), Jarvis Island (1.26 fish per km^2), Tau Island in American Samoa (1.08 fish per km^2), and Tutuila Island in American Samoa (0.41 fish per km^2) [1,7,9-14].

Degradation and loss of coral reef habitat threaten bumphead parrotfish [13]. The majority of parrotfish are found in mixed habitats (i.e., seagrass beds, mangroves, and rocky reefs). Approximately 78% of these mixed habitat species are experiencing greater than 30% loss of coral reef area and habitat quality across their distributions. Potential limiting factors of abundance include lack of sheltered habitat (lagoons) for recruitment, high-energy forereef foraging habitat for adults, and adult sleeping shelter (caves or reef tops) [7,13,15]. While they are not directly sensitive to ocean acidification, they are primarily corallivores and feed on benthic algae [1,2,4,10]. Impacts from stressors such as pollution and disease have not been reported.

<u>Life History Synopsis</u>**:**

In the Great Barrier Reef, pelagic spawning aggregations have been observed from depths between 2 and 15 m. Aggregations approximately consist of 100 individuals. Travel distance of the spawning aggregations has not been reported, although their range is less than 10 km [4,6,8,9,11]. Bumphead parrotfish may recruit at low levels throughout the year [13].

Planktonic larval duration is approximately 35 days for other species in the same family. Dispersal distance is not reported for this species; however, self-recruitment has been reported for other coral reef species. A model of passive pelagic particle connectivity in the main Hawaiian Islands determined that the median distance for successful settlement is 100 km and that cross-channel dispersal can be common given a pelagic larval duration of 45 days [5,16]. Oceanic eddies are also known to bring larvae to reefs on the leeward side of the island of Hawaiʻi [17]. Settlement may be cued by ambient sound and/or olfactory cues in coral reefs [18].

Juvenile bumphead parrotfish are found in seagrass beds and sandy shallow lagoons [9,19,20]. Adults occur in exposed reef crests and are usually in aggregations of over 75 individuals on seaward and clear outer lagoons reefs at depths of 1 to 30 m. *B. muricatum* can also enter outer reef flats during low tide to forage [4,7,8].

B. muricatum typically feed on benthic algae and coral. Using their large gibbus head, they ram and break coral into smaller pieces [1,2,4,10]. Their von Bertalanffy growth coefficient is 0.1 [7,21]. Some individuals have been reported to live up 40 years [22].

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Giant trevally - *Caranx ignobilis*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 93% of scores ≥ 2

	Caranx ignobilis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.8	3	
	Prey Specificity	1.5	2.8	
	Adult Mobility	1.5	3	
	Dispersal of Early Life Stages	1.4	1.6	
	Early Life History Survival and Settlement Requirements	2.1	1.7	
	Complexity in Reproductive Strategy	1.8	2.4	
	Spawning Cycle	1.8	2.8	
	Sensitivity to Temperature	1.1	3	
	Sensitivity to Ocean Acidification	1.6	2.6	
	Population Growth Rate	1.7	2.8	
	Stock Size/Status	2.2	2.1	
	Other Stressors	1.5	2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.3	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1.1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Giant Trevally (*Caranx ignobilis*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Early Life History and Settlement Requirements (2.1) and Stock Size/Status (2.2).

Distributional Vulnerability Rank: **[Very High].** Three attributes indicated very high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 93% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There has been no explicit study of the impacts of climate change on this species' distribution. However, giant trevally are a locally-abundant and widely-dispersed tropical species common across much of the Indo-Pacific tropical region and are capable of utilizing multiple habitats and depth ranges [1,2]. Giant trevally feed on a wide variety of fish and invertebrates, with fishes, cephalopods, and crustaceans comprising substantial parts of the diet [2,3]. Juveniles may be more dependent on fish prey [4].

Life History Synopsis**:**

Giant trevally are primarily benthic-associated, found on multiple habitat types including reefs, rocky habitats , and deep mixed habitat slopes, and at depths of down to 188 m [5]. Primary depth ranges vary among locations, with this species tending to be common in relatively shallow water (less than 30 m) in the Northwestern Hawaiian Islands, but typically more abundant in deeper water in the main Hawaiian Islands [1]. Juveniles are known to utilize estuaries and lagoons [4,6]. This species lives to at least 11 years of age and potentially longer given the relatively limited sampling that produced that maximum age; they reach sexual maturity at around 3.5 years old [2]. Their normal home range includes up to approximately 5 km of line distance but they are capable of greater travels, for example, moving to spawning sites within atolls [7]. It is speculated that they are capable of much longer movement, including between islands and atolls. Giant trevally are heavily targeted by sport fishers in Hawaiʻi, and perhaps as a consequence are much more abundant and tend to be larger in the remote Northwestern Hawaiian Islands [1,8].

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Bluefin trevally - *Caranx melampygus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 89% of scores ≥ 2

	Caranx melampygus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.6	2.8	
	Prey Specificity	1.7	2.8	
	Adult Mobility	2	2.6	
	Dispersal of Early Life Stages	1.7	1.8	
	Early Life History Survival and Settlement Requirements	2	0.8	
	Complexity in Reproductive Strategy	1.6	2	
	Spawning Cycle	1.9	2.4	
	Sensitivity to Temperature	1.4	2.6	
	Sensitivity to Ocean Acidification	1.6	2.4	
	Population Growth Rate	1.4	2.2	
	Stock Size/Status	2.2	2.2	
	Other Stressors	1.6	1.2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.3	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1.1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Bluefin Trevally (*Caranx melampygus*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.0), Early Life History and Settlement Requirements (2.0) and Stock Size/Status (2.2).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There has been no explicit study of the impacts of climate change on this species' distribution. However, bluefin trevally are a locally-abundant and widely-dispersed tropical species common across much of the Indo-Pacific tropical region and are capable of utilizing multiple habitats and depth ranges [1-3]. Bluefin trevally feed on a wide variety of fish and invertebrates but are primarily piscivorous as adults [3,4], although more dependent on crustaceans as juveniles [5]. Collectively, this species appears capable of thriving in a range of conditions and habitats and has a relatively wide diet, suggesting a reasonable ability to adapt to changing climate.

Life History Synopsis**:**

Bluefin trevally are primarily benthic-associated, found on multiple habitat types including reefs, rocky habitats, and deep mixed habitat slopes, and at depths of down to 230 m [6] although generally most abundant in depths of around 60 m or shallower [1,2]. Juveniles utilize estuaries and lagoons [5,7]. This species lives to at least 6 years of age and could potentially live longer given the relatively limited sampling that produced maximum age estimates. Bluefin trevally reach sexual maturity at around 2 years old [3].

Their normal home range includes up to around 10 km of line distance [8] but the species is capable of larger scale movements, including up to approximately 100 km [9]. Timing of spawning appears highly variable among locations [3]. They are commonly targeted through much of their range [10-12].

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Peacock grouper - *Cephalopholis argus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low

Climate Exposure = Very High

Data Quality = 89% of scores ≥ 2

	Cephalopholis argus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.3	3	
	Prey Specificity	1.6	3	
	Adult Mobility	2.3	3	
	Dispersal of Early Life Stages	1.6	2	
	Early Life History Survival and Settlement Requirements	2.3	1.4	
	Complexity in Reproductive Strategy	1.3	2	
	Spawning Cycle	2	3	
	Sensitivity to Temperature	1.2	3	
	Sensitivity to Ocean Acidification	2	2.8	
	Population Growth Rate	2.8	3	
	Stock Size/Status	1.3	2.6	
	Other Stressors	1.4	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Peacock Grouper (*Cephalopholis argus*)

Overall Climate Vulnerability Rank: **[Moderate].** (82% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.3), Adult Mobility (2.3), Early Life History and Settlement Requirements (2.3), and Population Growth Rate (2.8).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

This species occurs throughout 22 Spalding et al. [1] provinces, showing highly plastic demography and great variation over its distributional range [2]. Further, this grouper was introduced to Hawaiʻi from French Polynesia in 1955–1961 [3], indicating adaptability to local conditions [2]. Though they occur in a variety of habitats, they are most commonly inhabit exposed reef fronts, indicating close association with a fragile biogenic habitat [2, Giddens et al. in prep].

Life History Synopsis**:**

The peacock grouper is a relatively slow-growing, long-lived, coastal species that occurs from the Red Sea to South Africa and east to French Polynesia and the Pitcairn group, including northern Australia, Lord Howe Island, and Japan. This species was also introduced to Hawaiʻi from French Polynesia in 1955-1961 [3,4]. The demography of this species (i.e., maximum longevity, maximum size, and the VBGF parameters) is highly plastic and variable throughout its range. The dynamics of Hawaiʻi populations are more similar to the dynamics of the Indian Ocean populations rather than their parent populations in Moorea and the Marquesas [2]. Females in Hawaiʻi reach sexual maturity at 1.2 years [5]. Current information on spawning seasonality of this species is incomplete; however, the occurrence of spawning capable and actively spawning females suggests that spawning may occur from May to October in Hawaiʻi. Increased proportions of spawning capable and actively spawning females and an increased female gonado-somatic index during the first quarter and full-moon phases also indicate lunar spawning periodicity. Peacock grouper exhibit monandric protogyny (female gonad differentiation with female to male sex change). In Hawaiʻi, juveniles of this species are found more frequently in shallow rocky and coral habitat and are rarely seen in deeper waters with the adults. *Cephalopholis argus* inhabit various habitats but prefer exposed reef front habitats and have been recorded to at least 40 m [2]. A diet study comparing Moorea and Hawaiʻi populations found that both exhibited an ontogenetic shift towards larger prey occurred, but this shift was faster and more consistent in the Moorea population [6]. This species is a generalist predator. In Hawaiʻi, 97.7% of their diet consisted of fishes (the remainder were crustaceans) and was characterized by a wide taxonomic breadth. This variety of prey fishes suggests that feeding was not opportunistic. *C. argus* consumed aulostomid, holocentrid, and monacathid recruits as well as acanthurid and chaetodontid adults and juveniles [7]. Behavioral studies suggest that male *C. argus* defend large territories that incorporate smaller female territories as described for *C. boenak*. Additionally, male territory size increases with fish size. In the Gulf of Aqaba, *C. argus* is found in social units comprising up to 12 adults, including one dominant male. A territorial male defends a specific area (up to 2,000 m^2) which is split into secondary territories, each inhabited by a single female. A similar social organization has also been observed in Hawaiʻi populations [8-10]. In a removal and tagging experiment in Hawaiʻi, *C. argus* moved 50–150 from the periphery of the removal area to the vacant reef [11]. In a recent assessment of Hawaiʻi *C. argus* populations, the spawning potential ratio was 80%. When this species was introduced to Hawaiʻi from Moorea and the Marquesas, it successfully colonized and established large populations. *C. argus* are subject to increasing fishery pressure in some regions such as the Northern Mariana Islands, Guam, and Samoa. Landings examined at the three locations showed declines in the number of fish caught. In the Northern Mariana Islands, non-commercial fishery catches declined from 6 mt in 1952 to 1 mt in 2002. In Guam, landings were declining by 2001. In Samoa, the landings reached a high in the 1990s but have declined steeply since then. Localized protection is required at heavily fished sites to minimize the vulnerability of isolated populations to larger vessels [2,3,12,13].

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Ornate butterflyfish - *Chaetodon ornatissimus*

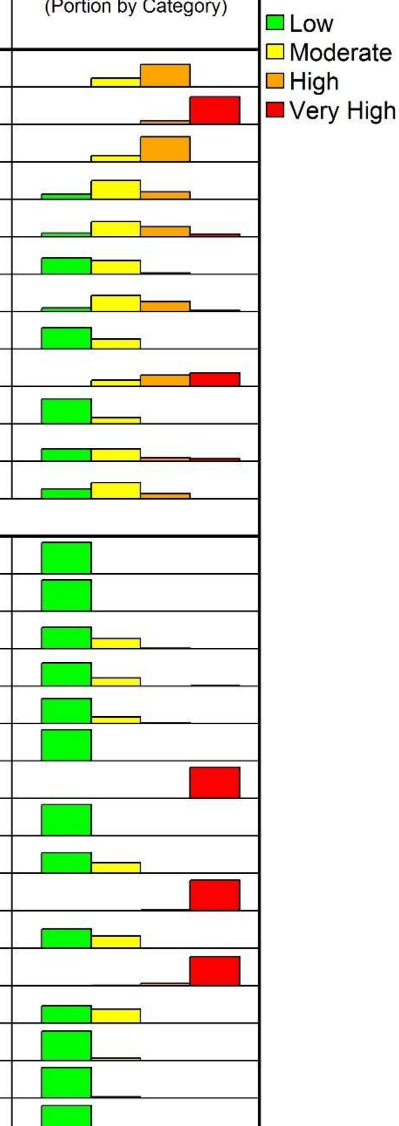
Overall Vulnerability Rank = Very High

Biological Sensitivity = High

Climate Exposure = Very High

Data Quality = 79% of scores ≥ 2

	Chaetodon ornatissimus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.7	3	
	Prey Specificity	3.9	3	
	Adult Mobility	2.8	3	
	Dispersal of Early Life Stages	2.1	2.2	
	Early Life History Survival and Settlement Requirements	2.4	1	
	Complexity in Reproductive Strategy	1.5	1.8	
	Spawning Cycle	2.3	1.4	
	Sensitivity to Temperature	1.3	2.8	
	Sensitivity to Ocean Acidification	3.2	2.8	
	Population Growth Rate	1.2	1.6	
	Stock Size/Status	1.9	1.8	
	Other Stressors	1.8	1.8	
	Sensitivity Score	High		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.5	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Very High		



Ornate Butterflyfish (*Chaetodon ornatissimus*)

<u>Overall Climate Vulnerability Rank</u>: **[Very High].** (96% certainty from bootstrap analysis).

<u>Climate Exposure</u>: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

<u>Biological Sensitivity</u>: **[High]**. Two sensitivity attributes scored above a 3.0: Prey Specificity (3.9) and Sensitivity to Ocean Acidification (3.2).

<u>Distributional Vulnerability Rank</u>: **[Low].** All four attributes indicated low vulnerability to distribution shift: adult mobility, limited early life stage dispersal, high habitat specialization, and sensitivity to temperature.

<u>Data Quality</u>: 79% of the data quality scores were 2 or greater.

<u>Climate Effects on Abundance and Distribution</u>:

Chaetodon ornatissimus feeds exclusively on live coral, making it susceptible to extensive coral loss [1]. This species relies on live coral for food and/or recruitment and was shown to decline following coral depletion in 1981 in a small part of its range, but has since recovered [1,2].

<u>Life History Synopsis</u>**:**

Ornate butterflyfish are widespread in the Indo-west Pacific from the Seychelles and Maldives to the Pitcairn group, north to southern Japan and the Hawaiian Islands, and south to Lord Howe and Rapa Iti Islands at depths of 1–36 m [1]. They are associated with coral reefs, which are vulnerable habitats [3]. Spawning aggregations have not been observed. This species forms pairs during breeding [4]. Though not reported specifically for this species, coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [5]. They inhabit coral-rich areas in lagoons and on outer reefs, but are most common in seaward reefs [1,6]. *C. ornatissimus* only consume live coral. Unlike other coral-feeding butterflyfishes, this species feeds on mucous rather than coral tissue. In a diet study in Hawaiʻi, *C. ornatissimus* had the broadest diet among corallivorous butterflyfishes and did not show preference for certain coral species [1,7,8]. This species exhibits home-ranging behaviour. The ornate butterflyfish considerably declined following coral loss at Moorea (French Polynesia) in 1981 but has since recovered. This species is listed as Least Concern by the IUCN as it has a wide range, is common, and faces no major threats other than coral loss [1,2].

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Tripletail wrasse - *Cheilinus trilobatus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 79% of scores ≥ 2

	Cheilinus trilobatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.2	2.6	
	Prey Specificity	1.8	2.4	
	Adult Mobility	2.5	2.4	
	Dispersal of Early Life Stages	1.9	2.2	
	Early Life History Survival and Settlement Requirements	2	1.4	
	Complexity in Reproductive Strategy	1.7	1.4	
	Spawning Cycle	2.1	1	
	Sensitivity to Temperature	1.4	2.6	
	Sensitivity to Ocean Acidification	2	2.4	
	Population Growth Rate	2.1	1.2	
	Stock Size/Status	1.7	1.8	
	Other Stressors	1.5	1.4	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.2	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Tripletail Wrasse (*Cheilinus trilobatus*)

Overall Climate Vulnerability Rank: **[Moderate].** (99% certainty from bootstrap analysis).

limate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.2) and Adult Mobility (2.5).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or changes in distribution of tripletail wrasse. *Cheilinus trilobatus* is broadly distributed in the Indo-Pacific, from East Africa to Tuamoto and from Japan to New Caledonia [1]. They are associated with coral reefs, which are vulnerable habitats [2].

Life History Synopsis**:**

Cheilinus trilobatus are widely distributed and common in the Indo-Pacific, from East Africa to Tuamoto and from Japan to New Caledonia [1]. They are associated with coral reefs, which are vulnerable habitats [2]. Juvenile *Cheilinus trilobatus* reside on algae reefs and usually around stinging hydrozoans [1,3]. Adults of this species are found in coral lagoon, coastal reef-flats, seaward reefs, along shallow reef margins with high coral cover, and grassy areas at depths of 1–30 m [1,4]. Prey of *Cheilinus trilobatus* consists of small fishes and hard-shelled benthic invertebrates such as sea urchins, mollusks, and crustaceans [1]. This species is not highly mobile. Though not reported specifically for this species, other Labrids have a home range size that spans between less than 0.1 and 10 km [5]. Coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [6]. Recent surveys in Indonesia, Papua New Guinea, and the Solomon Islands have recorded *Cheilinus trilobatus* [1] which have been assessed as Least Concern by the IUCN. However, because they are coral reef-associated, they may face habitat degradation as the oceans warm and become more acidic [1,7].

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Humphead wrasse - *Cheilinus undulatus*

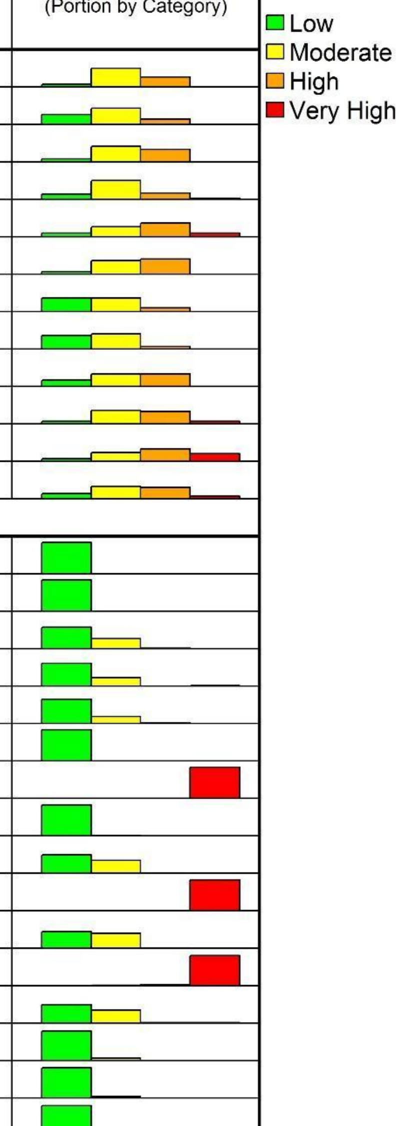
Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 93% of scores ≥ 2

	Cheilinus undulatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.2	2.8	
	Prey Specificity	1.8	2.2	
	Adult Mobility	2.3	2	
	Dispersal of Early Life Stages	2.1	2	
	Early Life History Survival and Settlement Requirements	2.6	1.6	
	Complexity in Reproductive Strategy	2.4	2.6	
	Spawning Cycle	1.7	2.2	
	Sensitivity to Temperature	1.6	2.2	
	Sensitivity to Ocean Acidification	2.2	2.4	
	Population Growth Rate	2.5	2	
	Stock Size/Status	2.8	2.2	
	Other Stressors	2.4	1.8	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		



Humphead Wrasse (*Cheilinus undulatus*)

Overall Climate Vulnerability Rank: **[High].** (97% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Early Life History and Settlement Requirements (2.6) and Stock Size/Status.

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 93% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There has been no explicit study of the impacts of climate change on this species' distribution. Humphead wrasse are widely distributed across coral reefs and inshore habitats throughout much of the tropical Indo-Pacific—exceptions include the Hawaiian archipelago [1,2]. Although widespread, they are not common [2,3]. Among U.S.-affiliated Pacific locations, they are most common at Wake and Palmyra, although they have also been recorded in Mariana Archipelago and American Samoa and several of the Pacific Remote Island Areas [4]. They are heavily fished at many locations and highly sought after for the live reef fish trade [2], which has resulted in significant depletion of their populations in several locations [5-7].

Life History Synopsis**:**

This species lives to at least 32 years, reaching sexual maturity at under 5 years [2]. Humphead wrasses have been observed spawning year round and are known to form spawning aggregations at sites that are consistently used over periods of several years [8].

They are found in a variety of habitats including steep outer reef slopes and channels at depths of up to at least 60 m, potentially to 100 m or more [2,3,6,9,10]. Young juveniles are strongly associated with coral thickets, often within lagoons [11], but larger juveniles may be found in a range of habitats including seagrass as well as coral and rubble [2]. Home range has been reported as about 5 hectares, but with some expectation that they are capable of longer term travels, for example, moving to spawning sites [12]. A more recent and longer-term study reported median home range over a 2-year period to span a distance of close to 10 km for female humphead wrasses and around 3 km for males [13]. Humphead wrasses feed on a variety of fishes and invertebrates, but the bulk of their diet appears to consist of crustaceans, gastropods, and echinoids [1].

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Tanned-faced parrotfish - *Chlorurus frontalis*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low

Climate Exposure = Very High

Data Quality = 64% of scores ≥ 2

	Chlorurus frontalis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.7	2.3	
	Prey Specificity	1.6	1.8	
	Adult Mobility	2.4	1.8	
	Dispersal of Early Life Stages	2.1	1.8	
	Early Life History Survival and Settlement Requirements	2.4	1.3	
	Complexity in Reproductive Strategy	2.1	1.7	
	Spawning Cycle	1.7	0.8	
	Sensitivity to Temperature	1.5	2.2	
	Sensitivity to Ocean Acidification	2	1.4	
	Population Growth Rate	1.8	1.2	
	Stock Size/Status	2.4	1.3	
	Other Stressors	2.1	1.2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.6	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.5	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Tanned-faced Parrotfish (*Chlorurus frontalis*)

Overall Climate Vulnerability Rank: **[Moderate].** 62% certainty in overall rank from bootstrap analysis.

Climate Exposure: **[Very High].** Three contributing climate exposure factors: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.7), Adult Mobility (2.4), Early Life History and Settlement Requirements (2.4), and Stock Size/Status (2.4).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 64% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is little information on the climate effects on the tanned-faced parrotfish's abundance and distribution. Several studies showed the presence of parrotfish in ecosystems located at higher latitudes [1-4]. Averdlund [5] suggested that the first detection of these species beyond its known range can be used as a predictor of climate change impacts. It is possible that environmental changes due to CO_2-induced warming at higher latitudes allow some parrotfish to thrive in temperate areas, thereby altering the herbivory rates in new areas being colonized [6].

Life History Synopsis**:**

Tanned-faced parrotfishes' range extends northward to the Ryukyu Islands and southward to the Great Barrier Reef. They are also found as far east as Micronesia, Line Islands, Tuamotu Archipelago, and Pitcairn Islands. This species also occurs in marginal reef areas at the southern limits (i.e., Middleton Reef, Rapa, and Pitcairn) and have been recorded from Halmahera, Indonesia. This was the most abundant large parrotfish recorded in Niue [7-9].

This large excavating parrotfish (50 cm total length) can be found at depths up to 40 m, foraging exposed reef crests and seaward reefs for benthic algae. This species is moderately limited in mobility; they are found in small groups on limited availability of seaward reefs [7,10-12]. They are not highly mobile, but their reported home range size is between 3 km and 5 km for core areas of use [13].

There is little to no information reported for reproductive strategy and early life stages. The tanned-faced parrotfish is known to use distinct pairing during breeding, but large spawning aggregations have not been reported [14]. There is no reported time frame for spawning, but other species in the same family have a lunar spawning periodicity. Coral reefs (rather than algae-dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [15]. Oceanic eddies bring larvae back to the reefs on the leeward side of Hawai'i Island [16]. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations [13]. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km [17]. It was reported for other species in the same family that spend about 35 days in the post-larval development phase.

The tanned-faced parrotfish is an herbivorous, coral reef-associated fish that may be dependent on the reef for shelter, especially in its juvenile stage [7]. Degradation and loss of coral reef habitats threaten coral reef-associated species [18]. The majority of parrotfish are found in mixed habitats (i.e., seagrass beds, mangroves, and rocky reefs), which are undergoing a reduction in habitat quality. More than 80% of species occuring exclusively in coral reef habitat are experiencing a greater than 30% of coral reef loss and degradation across their distributions [7,19].

This species is uncommon throughout most of its range. Catch records from Guam show that this is their seventh most exploited species. The total landed catch waned from 11,532 kg in 1985 to 4,805 kg in 2007. Recent underwater visual survey completed in 2008 at 28 sites in Guam suggested that this species is more commonly present inside marine reserves. This species' inclination for shallow habitat leave it susceptible to spearfishing [7,20]. In the 2012 report for Guam, the density of tanned-faced parrotfish was recorded at approximately 0.3 g/m^2 outside as opposed to approximately 2.8 g/m^2 inside marine reserves [21].

The tanned-face parrotfish has a maximum recorded age of 11 years for males and 9 years for females. The estimated age at sexual maturity was estimated to be roughly 2 years with a fork length of 240 mm [22]. The von Bertalanffy K parameter was estimated to be 0.71/year [23].

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Steephead parrotfish - *Chlorurus microrhinos*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 79% of scores ≥ 2

	Chlorurus microrhinos	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	3.2	2.2	
	Prey Specificity	2.1	2.2	
	Adult Mobility	2.6	2	
	Dispersal of Early Life Stages	1.9	2	
	Early Life History Survival and Settlement Requirements	2.8	1.7	
	Complexity in Reproductive Strategy	2.4	2.3	
	Spawning Cycle	1.8	1.2	
	Sensitivity to Temperature	1.4	2.2	
	Sensitivity to Ocean Acidification	2	1.8	
	Population Growth Rate	2	1.4	
	Stock Size/Status	2.4	1.3	
	Other Stressors	1.8	1.6	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.7	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.5	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Steephead Parrotfish (*Chlorurus microrhinos*)

Overall Climate Vulnerability Rank: **[High].** (83% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. One sensitivity attribute scored above a 3.0 and that is Habitat Specificity (3.2). The next highest score was Early Life History and Settlement Requirements (2.8).

Distributional Vulnerability Rank: **[Low].** Three attributes indicated low vulnerability to distribution shift: adult mobility, relatively high habitat specialization, and sensitivity to temperature. However, limited early life stage dispersal was scored as high which may mitigate the propensity of the species to shift distribution.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is little information on the climate effects on the steephead parrotfish's abundance and distribution. Several studies indicate the presence of parrotfish in ecosystems located at higher latitudes [1-4]. Arvedlund [5] suggested that the first detection of these species beyond its known range can be used as a predictor of climate change impacts. It is possible that environmental changes due to CO_2-induced warming at higher latitudes allow some parrotfish to thrive in temperate areas, thereby altering the herbivory rates in new areas being colonized [6].

Life History Synopsis**:**

Steephead parrotfish are found in the Indo-Pacific in Ryukyu and Ogasawara Islands to Indonesia and Australia, Lord Howe Island and New Caledonia, and eastwards to Oceania at depths up to 50 m (except Hawaiian Islands, Easter Island, and the Cocos Keeling Islands) [7-9]. This species is one of the more abundant and widely distributed Indo-Pacific parrotfishes and is moderately common, particularly at its southern limit.

Steephead parrotfish can reach a total length of 80 cm and are found in schools of up to 40 individuals on reef fronts and crests. They occur in habitats such as inshore reefs and exposed oceanic reef fronts [8,10]. Juvenile steephead parrotfish inhabit lagoons and seaward reefs generally in solitude [11]. This is an excavating herbivorous fish that feeds on benthic algae and macroalgae [11].

Steephead parrotfish are not a highly mobile species. They have a reported range size between less than 3 and up to 5 km for similar species in this family [12,13]. There are no early life history survival and settlement requirements for this species. It was reported that other species in the same family spend about 35 days in the post-larval development stage. For species in Hawaiʻi, oceanic eddies are known to bring larvae back to the reefs on the leeward side [14]. There has been no report of large spawning aggregations, but this species is known to use distinct pairing during breeding [15]. Steephead parrotfish are heavily fished in the Pacific Islands with the exception of Tuvalu due to ciguatera [8].

This species is coral reef-associated and may be limited physically by habitat requirements. Degradation and loss of coral reef habitats threaten coral reef-associated species [16]. Species occurring in mixed habitats are experiencing loss of coral reef area and habitat quality. More than 80% of species occuring exclusively in coral reef habitat are experiencing a greater than 30% of coral reef loss and degradation across their distributions [8,17].

Steephead parrotfish have a maximum recorded age of 11 years and the mean age of the oldest 25% of a sample from Micronesia was 5.9 years [18]. The age of sexual maturity was estimated to be 3.7 years [18]. The von Bertalanffy K parameter was estimated to be 0.34/year [18]. The maximum fork length recorded in a Micronesia-based study for steephead parrotfish was 50.1 cm [18]. The fork lengths at median maturity and median sex change were estimated to be 30.8 cm and 37.8 cm, respectively [18].

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Spectacled parrotfish - *Chlorurus perspicillatus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 86% of scores ≥ 2

	Chlorurus perspicillatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.4	2.2	
	Prey Specificity	1.7	2.4	
	Adult Mobility	2.6	2.2	
	Dispersal of Early Life Stages	2	2.2	
	Early Life History Survival and Settlement Requirements	2.4	1.4	
	Complexity in Reproductive Strategy	1.9	1.4	
	Spawning Cycle	2.3	2.4	
	Sensitivity to Temperature	2.1	2.6	
	Sensitivity to Ocean Acidification	1.8	2.2	
	Population Growth Rate	2.4	1.8	
	Stock Size/Status	2.1	2.2	
	Other Stressors	2.2	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	2.2	3	
	Bottom Temperature	2.3	3	
	Current EW	1.1	3	
	Current NS	1.1	3	
	Current Speed	1	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.5	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Spectacled Parrotfish (*Chlorurus perspicillatus*)

Overall Climate Vulnerability Rank: **[Moderate].** 61% certainty in overall rank from bootstrap analysis.

Climate Exposure: **[Very High].** Three contributing climate exposure factors: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.4), Adult Mobility (2.6), Early Life History and Settlement Requirements (2.4), and Population Growth Rate (2.4).

Distributional Vulnerability Rank: **[Moderate].** All four attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, relatively high habitat specialization, and sensitivity to temperature.

Data Quality: 86% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is little information on the impacts of climate to the spectacled parrotfish's abundance and distribution. Several studies have shown presence of parrotfish in ecosystems located at higher latitudes [1-4]. Averdlund [5] suggested that the first detection of these species beyond its known range can be used as a predictor of climate change impacts. It is possible that environmental changes due to CO_2-induced warming at higher latitudes allow some parrotfish to thrive in temperate areas, thereby altering the herbivory rates in new areas being colonized [6].

Life History Synopsis**:**

Spectacled parrotfish are found only in the main Hawaiian Islands, the Northwestern Hawaiian Island (NWHI) chain, and Johnston Atoll [7]. This herbivorous fish feeds on macroalgae and is often found alone or in small schools at depths up to 71 m over reef-associated areas [7]. The spectacled parrotfish are not highly mobile and may be physically dependent on coral reefs for shelter especially as juveniles [7,8]. Reported range migrations were under 3 and up to 5 km for similar species within the family *Chlorurus* [8].

The majority of parrotfish are found in mixed habitats (i.e., seagrass beds, mangroves, and rocky reefs), which are undergoing a reduction in habitat quality. More than 80% of species occuring exclusively in coral reef habitat are experiencing a greater than 30% of coral reef loss and degradation across their distributions [7,9].

Spectacled parrotfish are a coral reef--associated rather than algal dominated species. They may be limited physically by habitat requirements [7] and likely rely on eddies to retain larvae near settling grounds [10,11]. The duration of the planktonic eggs and larval life stages was reported to be about 35 days post-larval development for other species in the same family. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km, and cross-channel dispersal can be common [12].

Spectacled parrotfish are heavily fished recreationally and commercially in the MHI, which encompasses 30% of its total range. In the MHI and NWHI, biomass was recorded to be 0.01 tons/hectare and 0.14 tons/hectare, respectively. Large parrotfish typically have higher abundance in the NWHI. Abundance is estimated at 100 to 215 individuals per hectare in Pearl and Hermes, Kure, and Midway reefs; abundance estimates in the French Frigate Shoals suggest as many as 71 individuals per hectare [7,13-15]. No spawning aggregations have been observed for this species.

Spectacled parrotfish have a maximum recorded age of 19 years [16]. Their length at sexual maturity is estimated to be roughly 200 mm, with a spawning potential ratio of 0.54 [7]. The major period of ovarian development for this species is from March to June [7]. The von Bertalanffy K value was estimated to be 0.377/year , and natural mortality was estimated to be 0.17/year [16,17].

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Bullethead parrotfish - *Chlorurus spilurus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low

Climate Exposure = Very High

Data Quality = 89% of scores ≥ 2

	Chlorurus spilurus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.7	3	
	Prey Specificity	1.6	2.8	
	Adult Mobility	2.4	2.2	
	Dispersal of Early Life Stages	2	1.6	
	Early Life History Survival and Settlement Requirements	2.4	1.5	
	Complexity in Reproductive Strategy	2.2	2.1	
	Spawning Cycle	1.3	2.4	
	Sensitivity to Temperature	1.4	2.8	
	Sensitivity to Ocean Acidification	1.9	2.2	
	Population Growth Rate	1.6	2.5	
	Stock Size/Status	2.2	2.1	
	Other Stressors	2.2	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Bullethead Parrotfish (*Chlorurus spilurus*)

Overall Climate Vulnerability Rank: **[Moderate].** 54% certainty in overall rank from bootstrap analysis.

Climate Exposure: **[Very High].** Three contributing climate exposure factors: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.7), Adult Mobility (2.4), and Early Life History and Settlement Requirements (2.4).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, temperature sensitivity was scored as [Low], which may reduce the likelihood of the species to shift distribution.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is little information on the impacts of climate to the bullethead parrotfish's abundance and distribution. Several studies have shown presence of parrotfish in ecosystems located at higher latitudes [1-4]. Arvedlund [5] suggested that the first detection of these species beyond its known range can be used as a predictor of climate change impacts. It is possible that environmental changes due to CO_2-induced warming at higher latitudes allow some parrotfish to thrive in temperate areas, thereby altering the herbivory rates in new areas being colonized [6].

Life History Synopsis**:**

Bullethead parrotfish are commonly found in the central and western Pacific from the Ryukyu and Ogasawara Islands, Australia (Queensland), Micronesia, Hawaiian Islands, Line Islands, east to the Pitcairn Islands and Rapa [7,8]. There is no reported genetic variation between populations of this species.

This species is an active swimmer found in schools over coral rich reefs during the day, and in solitude resting in caves at night, sometimes encased in mucus [9-11]. Recruits prefer habitats composed of the branched coral *Porites compressa* over other corals [12]. Adults are found on coral reefs and in reef rubble from the surface down to 34 m [13,14]. Most individuals have discrete home ranges.

Bullethead parrotfish typically have higher biomass in coral habitats [13,14]. The majority of parrotfish are found in mixed habitats (i.e., seagrass beds, mangroves, and rocky reefs), which are undergoing a reduction in quality. More than 80% of species occuring exclusively in coral reef habitat are experiencing a greater than 30% of coral reef loss and degradation across their distributions [15,16].

The bullethead parrotfish are pelagic spawners, but their travel distance is unknown. However, other parrotfishes have been known to take long distance voyages, at least 400 m from their home ranges. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km, and cross-channel dispersal can be common [17-19]. When the larvae hatch, they are 1.6–1.7 mm, have a large yolk sac, unpigmented eyes, and an unformed mouth [11]. Coral reef species may be reliant on eddies to retain larvae near settling grounds [20,21].

Bullethead parrotfish are protogynous diandry/sequential hermaphrodites (i.e., undergoing a sex change from female to male), but some individuals develop directly into reproductively active males from their initial phase [9,11]. Territorial phase male individuals exhibit territorial behavior and protect the groups of females in their home ranges. These areas may be based on spawning sites and feeding habitat attractive to females [9-11,22]. For other species of parrotfish, larger females may produce more eggs in a batch proportional to their size, spawn over a longer time frame, or spawn with a greater frequency [9,11]. Additionally, reproductive activity of smaller, mature females quickly drops after the peak spawning period from May to July [9,22-24]. Bullethead parrotfish may have issues in recovering from low population sizes.

Bullethead parrotfish have a maximum recorded age of 13 years in Hawaiʻi [14]. The length at sexual maturity was estimated to be at 22 cm total length [9,14]. The von Bertalanffy K was estimated to be 0.59/year [14]. Natural mortality was estimated to be 0.26/year [14]. The maximum length recorded in a Hawaiʻi-based study was 508 mm [25]. The body length at median sexual maturity and median sex change were estimated to be 350 mm and 473 mm, respectively [25]. This species has an asynchronous spawning mode. The stock status has been estimated in the main Hawaiian Islands using a spawning potential ratio of 0.23, which is considered overfished [14,26].

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Bristle-toothed surgeonfish - *Ctenochaetus strigosus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 82% of scores ≥ 2

	Ctenochaetus strigosus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.4	2.6	
	Prey Specificity	1.5	2.4	
	Adult Mobility	2.4	2.2	
	Dispersal of Early Life Stages	1.8	1.8	
	Early Life History Survival and Settlement Requirements	2.1	1	
	Complexity in Reproductive Strategy	1.4	1.6	
	Spawning Cycle	2	2.6	
	Sensitivity to Temperature	1.8	2.6	
	Sensitivity to Ocean Acidification	1.8	1.8	
	Population Growth Rate	1.9	2	
	Stock Size/Status	1.8	2	
	Other Stressors	1.6	1.2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.7	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.3	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.5	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Bristle-toothed Surgeonfish (*Ctenochaetus strigosus*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.4) and Early Life History and Settlement Requirements (2.1).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 82% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of bristle-tooth surgeonfish. However, approximately 80% of surgeonfishes occurring exclusively in coral reef habitat are experiencing a greater than 30% loss of coral reef area. Approximately 80% of this species' range falls within the Papahanaumokuakea Marine National Monument, where extraction is prohibited [1].

Life History Synopsis**:**

Ctenochaetus strigosus are endemic to the Hawaiian Islands and Johnston Island. This species occurs mainly in shallow water, though they have been recorded down to 113 m depth [2,3]. Recruitment begins in May and is heaviest June through September [4,5]. This species spawns as a group or in pairs [6,7]. Eggs are buoyant and pelagic and most frequently follow the prevailing currents. Though not reported for this species, self-recruitment has generally been reported for a range of coral reef species and in a variety of locations. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km and cross-channel dispersal can be common [8-10]. This species may be reliant on eddies to retain larvae near settling grounds [11,12]. Though not reported specifically for this species, coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [13]. This species is found over coral, rock, and rubble. These detritivores utilize suction to consume substances comprised of diatoms, pieces of algae, organic material, and fine inorganic sediment [3,14]. They are not highly mobile; home range size is less than 0.3 km for similar species in the same family [8]. Though not reported for this species, other acanthurids are known to aggressively maintain territories [15]. Harvest is not a major threat to this species despite its popularity as an aquarium fish. Protected areas in West Hawaiʻi have experienced an overall increase in *C. strigosus* populations. Additionally, there have been high recruitment levels in fished areas, which allow densities to increase in protected areas. This species is listed as Least Concern by the IUCN [16-19]. Approximately 80% of surgeonfishes occurring exclusively in coral reef habitat are experiencing a greater than 30% loss of coral reef area and degradation of coral reef habitat quality. Approximately 80% of this species' range falls within the Papahanaumokuakea Marine National Monument, where extraction is prohibited [1].

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Blacktip grouper - *Epinephelus fasciatus*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 79% of scores ≥ 2

	Epinephelus fasciatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.1	
	Prey Specificity	1.4	2.5	
	Adult Mobility	2.5	2.2	
	Dispersal of Early Life Stages	2	1.6	
	Early Life History Survival and Settlement Requirements	2.6	1.4	
	Complexity in Reproductive Strategy	2.4	2.4	
	Spawning Cycle	2.7	1.8	
	Sensitivity to Temperature	1.6	2.3	
	Sensitivity to Ocean Acidification	1.6	2	
	Population Growth Rate	2.1	1.6	
	Stock Size/Status	2.3	1.5	
	Other Stressors	2.3	1.2	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
	Overall Vulnerability Rank	High		

Low
Moderate
High
Very High

Blacktip Grouper (*Epinephelus fasciatus*)

Overall Climate Vulnerability Rank: **[Very High].** (91% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.5) and Spawning Cycle (2.7).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of blacktip grouper. This species is associated with coral reefs, though has also been found on rubble [1-3]. The species is one of the two most widely distributed groupers.

Life History Synopsis**:**

The Indo-Pacific blacktip grouper range from the Red Sea to Port Alfred (South Africa), eastward to the Pitcairn Group, north to Japan and Korea, and south to the Arafura Sea, southern Queensland, and Lord Howe Island (Australia). The species is one of the two most widely distributed groupers [1, 4], and they exhibit simultaneous and sequential hermaphroditism. Smaller blacktip groupers within a social group exhibit simultaneous hermaphroditism; the largest no longer retain female function and reproduce exclusively as males [5]. In Sabah, Eastern Malaysia, blacktip groupers have been reported to spawn in aggregations [6], and they may utilize various depths in the water column during spawning aggregations [6]. Maximum age is reported at 19 years [3]. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations [7]. While *Epinephelus fasciatus* are reef-associated and occur in outer reef slopes at depths below 15 m to 160 m, they can occur on non-coral reefs areas such as protected bays and lagoons as shallow as 4 m. In Great Barrier Reef, Queensland, and Red Sea (southern Egypt), they are found in mid-shelf reefs and around dead coral blocks in seagrass beds, respectively [1-3]. In the Tuamotu archipelago, the species is reported to be a macro-carnivore. Throughout their range, blacktip groupers prey on a crustaceans, fish, octopus, and other invertebrates. [1,8,9]. This species is not highly mobile. Though not reported specifically for this species, other groupers of similar size have a home range size of less than 5 km [7]. This species likely maintains harems and territories similar to other groupers [10]. They have been assessed as Least Concern by the IUCN. However, overfishing and habitat degradation threaten certain sub-populations, and some areas in the Pacific have reported declines in catches. [1,11-15]. The greatest threat to *Epinephelus fasciatus* is loss of habitat from episodes of coral reef bleaching in their range that are likely to increase as sea surface temperature increases [1,16].

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Pacific longnose parrotfish - *Hipposcarus longiceps*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 79% of scores ≥ 2

	Hipposcarus longiceps	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.2	2.3	
	Prey Specificity	1.3	2	
	Adult Mobility	2.4	2.2	
	Dispersal of Early Life Stages	1.9	2	
	Early Life History Survival and Settlement Requirements	2.4	1.3	
	Complexity in Reproductive Strategy	2	1.9	
	Spawning Cycle	1.9	1.2	
	Sensitivity to Temperature	1.3	2.6	
	Sensitivity to Ocean Acidification	2	1.8	
	Population Growth Rate	1.5	2.2	
	Stock Size/Status	2.3	1.3	
	Other Stressors	1.8	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.5	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Pacific Longnose Parrotfish (*Hipposcarus longiceps*)

Overall Climate Vulnerability Rank: **[Moderate].** (85% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.4) and Early Life History and Settlement Requirements (2.4).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of Pacific longnose parrotfish. These herbivorous fish feed on macroalgae and are reef-associated so may be dependent on the reef for shelter, especially in the juvenile stage.

Life History Synopsis**:**

Hipposcarus longiceps are found in the Pacific Ocean from Cocos-Keeling Islands and Rowley Shoals in the eastern Indian Ocean to the Line and Tuamoto islands, northwards to the Ryukyu Islands, southwards to the Great Barrier Reef and New Caledonia [1,2]. They inhabit sand and rubble areas around shallow lagoon reefs, outer slopes in exposed continental reefs, and seaward reef flats. They have been observed in aggregations with females usually in small groups. Large adults may be found at depths of at least 40 m [1,3,4]. Other species in this family are reported to have lunar spawning periodicity and use distinct pairing during breeding. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations [5]. These fish are herbivores and feed on benthic algae. They are not highly mobile. Though not reported specifically for this species, other parrotfish of similar size have a home range size of under 3 to 5 km for core areas of use [5]. One study of their movements demonstrated that a species in the same family (*Scarus ghobban*) can carry out medium-scale movements (510–6,000 m) over bare soft bottoms between coral reef habitats [5,6]. This species is moderately limited in mobility as they occur in groups (behavioral constraint) and are associated with coral reefs, though also occur in sand and rubble areas. Degradation and loss of coral reef habitats are a threat to coral reef-associated species, such as parrotfish [1,7,8].

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Brown chub - *Kyphosus bigibbus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 82% of scores ≥ 2

	Kyphosus bigibbus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.7	2.2	
	Prey Specificity	1.2	2.6	
	Adult Mobility	2.1	2.8	
	Dispersal of Early Life Stages	1.4	2.4	
	Early Life History Survival and Settlement Requirements	1.9	1.4	
	Complexity in Reproductive Strategy	1.4	1.8	
	Spawning Cycle	1.6	2.8	
	Sensitivity to Temperature	1.2	2.6	
	Sensitivity to Ocean Acidification	1.6	2.4	
	Population Growth Rate	2.2	1.8	
	Stock Size/Status	1.3	1.8	
	Other Stressors	1.8	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1.1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Brown Chub (*Kyphosus bigibbus*)

Overall Climate Vulnerability Rank: **[Moderate].** (82% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.1) and Population Growth Rate (2.2).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution. [Note that all of these except habitat specialization are contradicted by information given in the Life History Synopsis below.]

Data Quality: 82% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

See the Life History Synopsis below for an explanation of the taxonomic complexity for the group of species that we include within the name brown chub. This species group occurs throughout 20 Spalding et al. [1] provinces in a variety of shallow, nearshore habitats in tropical and subtropical waters between 35°N and 38°S at depths of 0–42 m, but usually only to 25 m [2,3 as *K. bigibbus*]. There are no known studies of population changes, stock assessments, or studies of responses to climate change for brown chub species. Based on inferences from the general biology of other *Kyphosus* species, brown chubs appear to be moderately tolerant of changes to environmental conditions because of their highly dispersive early life stages (including a prolonged pelagic juvenile stage that associates with flotsam) and their ability to live in both coral and rocky reef habitats. In contrast, their restriction to shallow water habitats in all life stages may increase their vulnerability to the effects of climate change. Larvae and juveniles, which are found primarily near the sea surface, may be especially vulnerable. In addition, the anti-equatorial distributions of the species included herein as brown chubs [2] suggest that they are intolerant of very warm sea surface temperatures and may exhibit poleward range shifts with ocean warming. Fidelity to adult home ranges may also increase vulnerability. Adults are almost exclusively herbivorous, feeding on brown, red, and (to a lesser extent) green algae [4], although juveniles are probably omnivores like those of other *Kyphosus* species [5]. This near-obligate adult herbivory suggests that the vulnerability of brown chubs to climate change will vary with location. In regions where climate change results in decreased runoff or nutrient input, brown chub populations are expected to decrease. In contrast, these populations could increase at locations where climate change enhances algal productivity. Overall, utilization of shallow habitats, herbivorous feeding, and possible intolerance of equatorial sea surface temperatures will probably make brown chubs vulnerable to climate change impacts, potentially exacerbated by coastal development and nearshore pollution. The high dispersal ability of the species coupled with plasticity in habitat types used may increase their resilience to those effects.

<u>Life History Synopsis</u>**:**

Brown chubs, *Kyphosus bigibbus*, were long thought to be an Indo-Pacific species found from South Africa and the Red Sea to southern Japan, eastern Australia, and eastward to the Hawaiian Islands and Easter Island (e.g., by Sakai [6]). A series of taxonomic revisions resulted in the recognition of three similar and closely related species within that nominal taxon, with a complicated history of nomenclatural changes [2,7-9]. The global review by Knudsen and Clements [2] is the currently accepted taxonomy for this species group. The component species now recognized as valid in this group are: the brown chub, *Kyphosus bigibbus sensu stricto*, found in the Atlantic Ocean, Red Sea, Indian Ocean, and in the Pacific Ocean with an anti-equatorial distribution at Japan in the north and from eastern Australia to New Zealand and the Kermadec Islands to the south; the Hawaiian chub, *K. hawaiiensis*, which is probably an endemic Hawaiian Archipelago species; and the beaked chub, also known as the Bermuda sea chub, *K. sectatrix*, with a circumglobal, anti-equatorial distribution [2]. The three species form a monophyletic clade [10,11] that we herein refer to as the brown chubs or brown chub species group. Most of the published research on the ecology and life history of the brown chub in the Pacific relied on identifications using the recognition of only a single species prior to 2004. For that reason, and because the different species now recognized have different distributions among the islands considered in this vulnerability assessment, this review uses the name brown chub to include all of the species mentioned above.

Adult brown chubs are found from the surface to 42 m [3 as *K. bigibbus*], but usually only to 25 m at rocky shores, in lagoons, on reef flats, and at outer coral and rocky reefs [2,3 as *K. bigibbus*]. They can be patchily abundant, in monospecific groups or in aggregations with other *Kyphosus* species [2, 12 for *K. sectatrix*, 13 for *K. bigibbus*]. Brown chubs have a prolonged juvenile stage that can remain pelagic to at least 89 mm standard length [14, 15 both for *K. sectatrix*]. In the western Atlantic, juvenile *K. sectatrix* were found at temperatures of 23.6–29.0 °C and salinities of 35.4–36.5, which were suggested to be optimal ranges for that stage [15]. Larvae and juveniles are primarily hyponeustonic, associating with floating algae and other material [10,14]. The large pelagic juveniles appear to have the capability to continue the association with floating objects long after the time of usual settlement of most reef fishes to benthic habitats, which increases their dispersal [10]. [Note that this contradicts the inclusion of "limited early life history dispersal" in the three most highly ranked attributes for the High Distributional Vulnerability Rank at the beginning of this species narrative.] However, the limited range of the Hawaiian Islands endemic species *K. hawaiiensis* (see Knudsen and Clements [2]) suggests that it may have more limited dispersal capabilities than other brown chub species. Adults are mainly herbivorous, feeding on brown, red, and (to a lesser extent) green algae [4,16 both as *K. bigibbus*], although *K. sectatrix* is also known to feed on offal such as dolphin feces and garbage discarded from ships [12]. Juveniles are probably omnivores like those of other *Kyphosus* species [5]. There is presumably an ontogenetic transition from the carnivorous feeding in larval stages found in almost all fish larvae to omnivory in juveniles to nearly total herbivory in the adults. The feeding habits of kyphosids may make them more resilient to climate change than many species because warmer ocean temperatures are thought to be advantageous to digestion in herbivorous fishes and because kyphosids are thought to have been evolutionarily adaptable to a wider range of temperatures than many other herbivorous fishes [11]. However, the anti-equatorial distributions of some species included herein as brown chubs [2] suggest that they may be intolerant of the warmest sea surface temperatures found along the equator. Adults of at least some of the brown chub species maintain home ranges [17] and *K. hawaiiensis* is thought to be territorial [18]. The home ranges of *K. sectatrix* can be between 30,000 and 40,000 m^2 (0.03–0.04 km^2) and the fish appear to have high fidelity to them [17]. A study of brown chub movements at western Australia found that 47% of the tagged fish did not remain in the study area; one traveled 138 km away from the tagging site in 8 months [19], suggesting the capability of long-term dispersal by adults is similar to that seen in other *Kyphosus* species. [Note that this contradicts the inclusion of adult mobility in the three most highly ranked attributes for the High Distributional Vulnerability Rank at the beginning of this species narrative.] The resident individuals had the largest home ranges found for any herbivorous fish species—0.27 ± 0.03 50% km^2 kernel utilization and 1.61 ± 0.30 km^2 90% kernel utilization. The only direct estimate of pelagic larval duration for a brown chub species is 20 days from reared larvae [20]. That estimate was for a species identified as *K. sandwicensis*, a synonym for the eastern Pacific species *K. elegans*. The most often used guide to Hawaii shorefishes [7], probably the source for the identification of the reared larvae, assigned *K. sandwicensis* as the name for chubs now recognized as *K. hawaiiensis* and *K. sectatrix* [2]. It is not possible to determine which species was reared to obtain the estimate of pelagic larval duration. However, pelagic larval duration is not relevant to the dispersal capability of this species because of its long pelagic juvenile stage. *Kyphosus sectatrix* can be either a pair or group spawner with focal spawning sites and spawning aggregations of up to 200 individuals [21]. The use of focal spawning sites may increase its vulnerability to climate change. The spawning season off Puerto Rico is January through March, with spawning at 0–11 days after a full moon and peak spawning 60–80 days after the winter solstice [21]. *Kyphosus bigibbus* are indeterminate multiple-batch spawners and no evidence has been found that they are hermaphroditic [22]. In Kyushu, Japan, the spawning season is from June to October. The fork lengths at 50% maturity are 248 mm for males and 360 mm for females [22]. Brown Chub eggs are about 0.95 mm in diameter and the larvae hatch at about 2.6 mm total length [20], usual sizes for tropical reef-fish species. There is almost no other life history information for these species. For the purposes of this assessment, von Bertalanffy K was estimated as 0.12 and the maximum age was estimated as 24 years, both from theoretical growth modeling, but those estimates need empirical verification. Maximum total lengths are given as 59.5 cm for *K. bigibbus* [2], 41 cm for *K. hawaiiensis* with larger sizes expected [7], and 76 cm for *K. sectatrix* [12]. There are no known estimates of stock sizes or changes in stock status for brown chub species. They are taken by local, small-scale fisheries [12 for *K. sectatrix*]. *Kyphosus bigibbus sensu stricto* and *K. sectatrix* are currently listed as Least Concern by the IUCN [12,13].

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Brassy chub - *Kyphosus vaigiensis*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 79% of scores ≥ 2

	Kyphosus vaigiensis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.7	3	
	Prey Specificity	1.2	3	
	Adult Mobility	1.8	3	
	Dispersal of Early Life Stages	1.4	2.5	
	Early Life History Survival and Settlement Requirements	2	0.8	
	Complexity in Reproductive Strategy	1.4	1.2	
	Spawning Cycle	1.7	1.9	
	Sensitivity to Temperature	1.4	2.8	
	Sensitivity to Ocean Acidification	1.7	2.2	
	Population Growth Rate	2.5	1.2	
	Stock Size/Status	1.8	1.6	
	Other Stressors	1.8	1.6	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Brassy Chub (*Kyphosus vaigiensis*)

Overall Climate Vulnerability Rank: [Moderate]. (100% certainty from bootstrap analysis).

Climate Exposure: [Very High]. Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: [Low]. No sensitivity attributes scored above a 3.0. The highest scores were for Early Life History and Settlement Requirements (2.0) and Population Growth Rate (2.5).

Distributional Vulnerability Rank: [High]. Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. [Note that the first two are contradicted by information given in the Life History Synopsis below.] However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

This species occurs throughout 17 Spalding et al. [1] provinces in a variety of shallow, nearshore habitats in tropical and subtropical waters from 35°N–38°S at depths of 0–20 m [2,3]. There are no known studies of population changes, stock assessments, or studies of responses to climate change for brassy chub. Based on inferences from its general biology, brassy chub appear to be moderately tolerant of changes to environmental conditions because oftheir highly dispersive early life stage (including a prolonged pelagic juvenile stage that associates with flotsam), its ability to live in both coral and rockyreef habitats, and its adult mobility. In contrast, its restriction to shallow-water habitats in all life-history stages may increase its vulnerability to the effects of climate change. Larvae and juveniles, which are found primarily near the sea surface, may be especially vulnerable. Adults are almost exclusively herbivorous, feeding on brown, red, and (to a lesser extent) green algae [4], although juveniles are omnivores [5 as *K. incisor*]. This near-obligate adult herbivory suggests that the vulnerability of brassy chub to climate change will vary with location. In regions where climate change results in decreased runoff or nutrient input, brassy chub populations are expected to decrease. In contrast, brassy chub populations could increase at locations where climate change enhances algal productivity. Overall, utilization of shallow habitats and herbivorous feeding will probably make the brassy chub vulnerable to climate change impacts, potentially exacerbated by coastal development and nearshore pollution. The high dispersal ability of the species coupled with plasticity in habitat types used may increase its resilience to those effects.

Life History Synopsis:

Brassy chub were considered to be a widely distributed Indo-Pacific species prior to the revision of the genus by Knudsen and Clements [3; e.g.; 6,7]. Knudsen and Clements [3] determined that the nominal eastern Pacific and Atlantic Oceans species *Kyphosus analogous* and *K. incisor* are conspecific with *K. vaigiensis*. As a consequence, the brassy chub is now known to have a circum-tropical and subtropical distribution between 35° N and 38° S [2,3]. In the Pacific they occur from Panama and Mexico across to Easter Island, Hawaiʻi, Japan, Australia, and New Zealand. Adult brassy chub are found from the surface to 25 m at rocky shores, in lagoons, on reef flats, and at outer coral and rocky reefs [3]. They can be patchily abundant at some locations, sometimes in monospecific groups or in aggregations with other *Kyphosus* species [3,8]. Brassy chub have a prolonged juvenile stage that can remain pelagic to at least 104 mm standard length [9,10 as *K. incisor*]. In the western Atlantic, juvenile *K. vaigiensis* were found at temperatures of 23.9–28.9 °C and salinities of 27.8–36.5 [10 as *K. incisor*]. Larvae and juveniles are primarily hyponeustonic, associating with floating algae and other objects [9,11]. The large pelagic juveniles appear to have the capability to continue the association with floating objects long after the time of usual settlement of most reef fishes to benthic habitats [9,12], which increases their dispersal [13]. [Note that this contradicts the inclusion of "limited early life history dispersal" in the three most highly ranked attributes for the High Distributional Vulnerability Rank at the beginning of this species narrative.] Adults are almost exclusively herbivorous, feeding on brown, red, and (to a lesser extent) green algae [4], although juveniles are omnivores [5]. There is presumably an ontogenetic transition from the carnivorous feeding in larval stages found in almost all fish larvae to omnivory in juveniles to nearly total herbivory in the adults. The feeding habits of kyphosids may make them more resilient to climate change than many other species because warmer ocean temperatures are thought to be advantageous to digestion in herbivorous fishes, and because kyphosids are thought to have been evolutionarily adaptable to a wider range of temperatures than many other herbivorous fishes [14]. Adult brassy chub cover, on average, a 2.5 km length of reef (11 km maximum) each day while foraging [2] but can move over as much as 300 km, even between islands, on rare occasions [15]. [Note that this contradicts the inclusion of "limited early life history dispersal" in the three most highly ranked attributes for the High Distributional Vulnerability Rank at the beginning of this species narrative.] There are no direct estimates of pelagic larval duration for the brassy chub; however, pelagic larval duration is not relevant to the dispersal capability of this species because of its long pelagic juvenile stage. There is no information on early life history requirements for this species other than its association with floating material in the hyponeuston, and no information on its settlement requirements. There is little information on reproduction of the brassy chub. The length at maturity for females is about 36 cm [2]. Kyphosids in general are batch spawners [16] and no evidence has been found that they are hermaphroditic. Brassy chub eggs are about 1.0–1.1 mm in diameter and the larvae hatch at about 3 mm notochord length [17], usual sizes for tropical reef-fish species. There is almost no other life history information for this species. For the purposes of this assessment, von Bertalanffy K was estimated as 0.13 and the maximum age was estimated as 22 years, both from theoretical growth modeling, but those estimates need empirical verification. The maximum total length is given variously as 60 cm [6,7], 77 cm [18], or 90 cm [2]. There are no known estimates of stock sizes or changes in stock status for the brassy chub. They are taken by local, small-scale fisheries [2]. There is research on the potential of this species in aquaculture. Brassy chub are currently listed as Least Concern by the IUCN [2].

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Marbled parrotfish - *Leptoscarus vaigiensis*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 86% of scores ≥ 2

	Leptoscarus vaigiensis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.2	2.6	
	Prey Specificity	1.4	2.8	
	Adult Mobility	2.6	2.4	
	Dispersal of Early Life Stages	2.1	2	
	Early Life History Survival and Settlement Requirements	2.2	1.8	
	Complexity in Reproductive Strategy	1.6	2	
	Spawning Cycle	1.2	2.4	
	Sensitivity to Temperature	1.2	2.6	
	Sensitivity to Ocean Acidification	1.8	2.2	
	Population Growth Rate	1.3	1.9	
	Stock Size/Status	2.3	1.2	
	Other Stressors	1.9	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.2	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Marbled Parrotfish (*Leptoscarus vaigiensis*)

Overall Climate Vulnerability Rank: **[Moderate].** (80% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.6) and Stock Size/Status (2.3).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 86% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of marbled parrotfish. These herbivorous fish feed on seagrasses and algae. They are reef-associated so may depend on the reef for shelter, especially in the juvenile stage [1]. Juveniles are associated with seagrass beds, which are vulnerable habitats [2-4].

Life History Synopsis**:**

This species is found in the Indo-Pacific from the northern Red Sea and South Africa to Easter Island, northwards to southern Japan, southwards to Poor Knights Island in New Zealand, and Rottnest Island in Australia [2,5]. Depth of occurrence ranges from 1 to 15 m [6]. In one study, larvae and juveniles of *L. vaigiensis* occurred generally throughout the whole year, drifting with algae off of Okinawa, Japan. *L. vaigiensis* collected from July to October were associated with drifting algae composed of *Sargassum* spp. Larvae and early juveniles (11.1 to 14.9 mm standard length, SL) were observed irregularly year-round, and post flexion larvae (much smaller than 11 mm SL) were observed from July to November [7]. This species spawns in shallow water above grassflats on the falling tide. Drifting algae may act as a nursery for *L. vaigiensis*, as well as provide dietary requirements for the early stages [7]. This species inhabits sheltered bays, harbors, lagoons, seagrass areas, or areas with hard substrates heavy and algal cover. It usually occurs in small groups. In a study off of Okinawa, Japan, subadult biomass was predicted by distance to neighboring coral habitat [2-4]. They are not highly mobile. Though not reported specifically for this species, other parrotfish of similar size have a home range size of under 3 to 5 km for core areas of use [8]. They are associated with coral reefs and seagrass beds and may be limited to these habitats [2-4].

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Orange-striped emperor - *Lethrinus obsoletus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 86% of scores ≥ 2

	Lethrinus obsoletus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.2	2.8	
	Prey Specificity	1.8	2.7	
	Adult Mobility	2.6	3	
	Dispersal of Early Life Stages	1.7	1.4	
	Early Life History Survival and Settlement Requirements	2.2	1.3	
	Complexity in Reproductive Strategy	1.9	2	
	Spawning Cycle	1.6	1.2	
	Sensitivity to Temperature	1.4	2.8	
	Sensitivity to Ocean Acidification	1.8	2.2	
	Population Growth Rate	2.2	2.7	
	Stock Size/Status	2.2	2.8	
	Other Stressors	1.9	2.2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Orange-striped Emperor (*Lethrinus obsoletus*)

Overall Climate Vulnerability Rank: **[Moderate].** (93% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest score was for Adult Mobility (2.6).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 86% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Although climate change effects on this species have not been specifically evaluated, the habitats associated with the orange-striped emperor have been assessed. Bell et al. [1] projected significant declines in live coral cover and seagrass through 2100, two habitats that constitute shallow-water lagoons where orange-striped emperor are most abundant [2]. In Saipan Lagoon, a primary habitat for orange-striped emperor, a habitat mapping study by Houk and van Woesik [3] found considerable reductions in coral habitats and the seagrass *Halodule uninervis* from the late 1940s [4] to 2004, while the seagrass *Enhalus acoroides* increased. Kendall et al. [5] found declines in *Halodule uninervis* from 2001 to 2016, and a study in Guam by LaRoche et al. [6] found *E. acoroides* seagrass meadows declined 22% between 2004 and 2015. The degree to which such habitat changes are influenced by climate change, expanded human populations, and associated point and non-point source nearshore inputs, or both, remains to be determined.

Life History Synopsis**:**

Orange-striped emperor are widely distributed in the Indo-Pacific Region from the Red Sea to French Polynesia [2]. The species is associated with seagrass beds, sand, coral, and rubble habitats to depths of about 30 m [7]. The reproductive ontogeny of the species has been confirmed in two cases as protogynous juvenile hermaphroditism, where individuals initially develop as immature females with some percentage changing to male prior to sexual maturation [8,9]. The spawning period for the species has been identified as being from April to October in the Ryukyu Islands of Japan [8], and although no evidence of a distinct annual spawning season was observed by in the southern Commonwealth of the Mariana Islands (CNMI), evidence for monthly spawning periodicity coinciding with the new moon was documented [9]. Orange-striped emperor females were estimated to attain 50% sexual maturity at 22.9 cm fork length (FL) and 3.8 years in the CNMI [9], while Ebisawa [8] described female maturation to increase at 22 cm FL achieving 90% at 26 cm FL, and Ebisawa and Ozawa [10] found age at 50% sexual maturity to be 2–3 years. Taylor et al. [9] described 50% male sexual maturity to be reached at 19.9 cm FL at 2.8 years of age. The maximum age of orange-striped emperor was estimated at 14 years in New Caledonia [11]; Ebisawa and Ozawa [10] found maximum age for males to be 18 years and females 21 years in the Ryukyu Islands; Taylor et al. [9] found the maximum age of a female to be 13 years as sampled from the Saipan-based nighttime commercial spear fishery. Age and growth estimates from the Ryukyu Islands are 31.3 cm FL for asymptotic length and 0.276 for growth [10], while Taylor et al. [9] estimated those parameters to be 25.3 cm FL for females and 24.8 cm FL for males, with corresponding estimates of growth of 0.594 for females and 0.611 for males. The greater maximum age, larger asymptotic length, and slower growth the orange-striped emperor estimated from the Ryukyu Islands of Japan compared to Saipan in the CNMI may reflect the influence of ambient temperature on those life history parameters for this species, with CNMI sea surface temperatures being about 3 °C warmer than the Ryukyu Islands [9]. At Ishigaki Island In the southern Ryukyu Islands of Japan, Nakamura et al. [12] estimated the orange-striped emperor to settle at a size of 14.2 mm, with 25.5 days corresponding to the pelagic larval duration phase. Lethrinidae larvae were found to favor settlement in seagrass habitats at Ishigaki Island, with larger-sized juvenile orange-striped emperors (30-40 mm TL) also observed in those habitats [13]. Ontogenetic habitat shifts for the orange-striped emperor in the Ryukyu Islands have been documented by Shinbuno et al. [14], who observed small individuals (12 cm TL and less) in seagrass beds, with larger individuals found in coral rubble, branching coral, and tabular coral habitats. The diet of adult orange-striped emperor consists of invertebrate fauna including echinoderms, mollusks, polychaete worms, and benthic crustaceans such as copepods, amphipods, and mysids [15,16]. The home range of the orange-striped emperor was estimated on Guam to be approximately 0.8 ha, which may lend it to be a species that can benefit from marine protected areas [17].

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Two spot snapper - *Lutjanus bohar*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 82% of scores ≥ 2

	Lutjanus bohar	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.9	3	
	Prey Specificity	1.6	2.8	
	Adult Mobility	2.5	2	
	Dispersal of Early Life Stages	2.2	1.6	
	Early Life History Survival and Settlement Requirements	2.2	1.2	
	Complexity in Reproductive Strategy	1.4	2	
	Spawning Cycle	1.3	1.8	
	Sensitivity to Temperature	1.4	2	
	Sensitivity to Ocean Acidification	1.8	1.6	
	Population Growth Rate	2.7	2	
	Stock Size/Status	1.6	2	
	Other Stressors	1.4	1	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
	Overall Vulnerability Rank	High		

Low
Moderate
High
Very High

Two-spot Snapper (*Lutjanus bohar*)

Overall Climate Vulnerability Rank: **[High].** (53% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.5) and Population Growth Rate (2.7).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 82% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of the two-spot snapper. However, this species is intrinsically vulnerable to overexploitation due to its longevity and late age at first maturity [1,2]. Degradation and loss of coral reef habitats threaten coral reef-associated species [3].

Life History Synopsis**:**

Lutjanus bohar are widespread in the Indo-West Pacific [2,4,5]. This species is found at depths ranging from 10 to at least 70, possibly 170 m [2]. The age at maturity is 4.3 years, and the reproductive lifespan (RLS) is estimated at 12.2 years. Age at 50% maturity for females was estimated at 9.39 years in the the Great Barrier Reef [1,2,6]. The maximum age (mean age in published literature) of *L. bohar* is estimated at 16.5 years, but they may live 55+ years based on evaluation from the Great Barrier Reef [1,2,6]. Although spawning occurs throughout the year in lower latitudes, temperature may be a spawning cue in higher latitudes, where peak spawning occurs in summer months [2,4]. This species is an open water/substratum egg scatterer. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations [7]. This species inhabit coral reefs, including sheltered lagoons and outer reefs, and are frequently found individually, athough they also occur in groups [8,9]. Their main prey is fish, but also consume shrimps, crabs, amphipods, stomatopods, gastropods, and urochordates [2]. This species is not highly mobile. Though not reported specifically for this species, other Lutjanids have a home range size of less than 1 km [7]. This species is assessed as Least Concern by the IUCN. A NOAA survey from 2008 to 2014 estimated *L. bohar* density in the Pacific coral reef areas to be approximately 5 to 90 individuals per hectare over hard bottoms to 30 m depth (NOAA unpublished data as described in [10]). Areas with less fishing pressure (e.g., U.S. Line and Phoenix Islands) were reported to have greater density of *L. bohar* (28 to 169.6 individuals per hectare) in contrast to the southern Marianas Islands (1 to 10 individuals/ha). However, their longevity and late age at first maturity make this species susceptible to over-exploitation [1,2]. Degradation and loss of coral reef habitats are a threat to coral reef-associated species [11].

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Bluestripe snapper - *Lutjanus kasmira*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 93% of scores ≥ 2

	Lutjanus kasmira	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.9	3	
	Prey Specificity	1.2	2.9	
	Adult Mobility	2.2	3	
	Dispersal of Early Life Stages	1.8	2.2	
	Early Life History Survival and Settlement Requirements	2.1	1.3	
	Complexity in Reproductive Strategy	1.6	1.1	
	Spawning Cycle	1.2	2.8	
	Sensitivity to Temperature	1.2	3	
	Sensitivity to Ocean Acidification	1.7	2.4	
	Population Growth Rate	1.7	2.7	
	Stock Size/Status	1.4	2.8	
	Other Stressors	1.6	2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	2.9	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Legend: Low, Moderate, High, Very High

Bluestripe Snapper (*Lutjanus kasmira*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.2) and Early Life History and Settlement Requirements (2.1).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 93% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There has been no explicit study of the impacts of climate change on this species' distribution. However, one study based on survey data from the Great Barrier Reef found little evidence of changes in abundance of this species following large disturbance events, including bleaching and mortality [1], which would be consistent with them having little dependence on live coral cover.

They are found in a variety of habitats including reef slopes and a range of deeper habitats, usually deeper than 15 m and down to at least 265 m [2,3]. They appear to prefer mixed habitats with both physical structure and proximity to sand [1,4].

Bluestripe snapper are important fishery targets in some parts of their natural range [5]. Although not initially favored by local fishers after their deliberate introduction to the Hawaiian Islands, they have been more targeted in recent years [6]. Their populations indicate moderate depletion [7].

Life History Synopsis**:**

This species lives to at least 8 years [7]. Juveniles have been observed on artificial reefs at approximately 60 m deep in the main Hawaiian Islands [8]. Larval pelagic duration has been reported as being between 25 and 47 days; mean realized dispersal distance calculated as 33–130 km based at least in part on the rate of spread of the species after introduction into the Hawaiian archipelago [9].

Home range has been thoroughly established for this species. A study in Kauai in the Hawaiian Islands suggested that bluestripe snapper generally exhibit a high degree of site fidelity, with the large majority of detected movements being less than 150 m from the site of initial capture [2]. A different study at Oahu (also Hawai'i) suggested routine movements were potentially quite variable among individuals and habitats [10]. Although primarily observed over hardbottom or associated with physical structure during the daytime, individuals of this species disperse to forage at night, including (particularly for smaller individuals) movements into nearby soft bottom habitats [2,10]. Bluestripe snapper feed primarily on epibenthic crustaceans and small fishes [10].

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Humpnose big-eye bream - *Monotaxis grandoculis*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 79% of scores ≥ 2

	Monotaxis grandoculis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.4	
	Prey Specificity	1.6	2.4	
	Adult Mobility	2.4	1.6	
	Dispersal of Early Life Stages	1.8	1.8	
	Early Life History Survival and Settlement Requirements	2.4	0.8	
	Complexity in Reproductive Strategy	1.8	0.8	
	Spawning Cycle	2	0.6	
	Sensitivity to Temperature	1.3	2.6	
	Sensitivity to Ocean Acidification	1.8	2.2	
	Population Growth Rate	2.3	2.2	
	Stock Size/Status	1.9	2.2	
	Other Stressors	1.8	1	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1.1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Humpnose Big-eye Bream (*Monotaxis grandoculis*)

Overall Climate Vulnerability Rank: **[Moderate].** (83% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.4) and Early Life History and Settlement Requirements (2.4).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Humpnose big-eye bream are widely distributed in the Indo-Pacific Region from the Pitcairn Islands to East Africa into the Red Sea, and southern Japan to Australia [1]. The species has also been described as a Lessepsian migrant from the Red Sea into the Mediterranean Sea [2]. It is found on sand and rubble areas near coral reefs, often solitary but sometimes in aggregations up to 50 individuals, at depths from 5 to 30 m [3]. Humpnose big-eye bream have also been associated with schooling behavior on WWII wrecks in Saipan Lagoon [4]. In a study from French Polynesia, Lecchini and Galzin [5] found juvenile humpnose big-eye bream to be associated with fringing coral reefs closer to shore; adults' more distal habitats are associated with the barrier reef. Increasing oceanic temperatures have resulted in shifts in benthic communities in southern Japan from macroalgal to coral dominance [6,7]. Although poleward latitudinal shifts in coral reef ecosystem communities could expand coral reef fish ranges, distributional expansion may be mediated by the loss of tropical coral communities and associated oceanographic changes [8]. Climate change alterations of current patterns and sea surface temperatures are predicted to impact connectivity in reef fish populations [9]. Having a pelagic larval stage of unknown duration may therefore impact larval dispersal for the humpnose big-eye bream. Ocean acidification is predicted to have a negative effect on the sensory abilities of pelagic larval reef fish, which will impact the ability of pelagic larvae to spatially orient, locate settlement habitat, and adjust vertical distribution resulting in predicted declines in the recruitment of demersal reef fish species [10].

Life History Synopsis**:**

Humpnose big-eye bream are benthic carnivores that feed nocturnally on a diet consisting of crabs, bivalves, mollusks, and polychaete worms [11]. The maximum length for the species is estimated to be about 55 cm fork length (FL) [12], and the largest specimen from the Northern Mariana Islands has been recorded at 49 cm FL [13]. Nadon [14] used a step-wise stochastic simulation approach to estimate life history parameters for the humpnose big-eye bream, producing growth (K) at 0.37, maximum age at 21 years, and natural mortality at 0.15. A rapid histological assessment technique employed by Longenecker and Langston [15] on specimens collected in Pohnpei, Federated States of Micronesia, to estimate humpnose big-eye bream female size at 50% sexual maturity (L_{50}) at 27.5 cm FL, based on a small sample size with high uncertainty. In the same study, humpnose big-eye bream fecundity was estimated at 80,875 eggs at a mean length of 30.4 cm FL (n = 4). In contrast to emperor species of the genus *Lethrinus* that exhibit hermaphroditism, gonochoristic reproduction has been preliminarily observed in the humpnose big-eye bream in Pohnpei [15]. There is no information pertaining to annual or lunar spawning periodicity for the humpnose big-eye bream. Meyer et al. [16] found that an electronically tagged humpnose big-eye bream in a 1.5 km^2 Hawaiʻi Marine Protected Area (MPA) did not leave the MPA over a detection span of 5-days and 164 detections.

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Yellowstripe goatfish - *Mulloidichthys flavolineatus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 89% of scores ≥ 2

	Mulloidichthys flavolineatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.9	2.6	
	Prey Specificity	1.6	2.4	
	Adult Mobility	2.3	2.4	
	Dispersal of Early Life Stages	1.8	2.6	
	Early Life History Survival and Settlement Requirements	2.2	1.4	
	Complexity in Reproductive Strategy	2.1	1.6	
	Spawning Cycle	1.4	2	
	Sensitivity to Temperature	1.3	2.4	
	Sensitivity to Ocean Acidification	1.8	2.4	
	Population Growth Rate	1.4	2	
	Stock Size/Status	1.6	1.8	
	Other Stressors	2.2	2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Yellowstripe Goatfish (*Mulloidichthys flavolineatus*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.3), Early Life History and Settlement Requirements (2.2), and Other Stressors (2.2).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution. The limited early life stage dispersal seems questionable, given the genetic connectivity between populations throughout this species' range [1].

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Yellowstripe goatfish are associated with and may be dependent upon coral reefs, which are a biogenic habitat vulnerable to ocean warming and acidification. The prey of yellowstripe goatfish includes some species with a calcium carbonate shell, but these are not major or irreplaceable components of the diet. Pollution and coastal development threaten the habitat of yellowstripe goatfish in some areas. The occurrence of larvae and pelagic juveniles of goatfishes almost exclusively in the upper few meters of the water column, often in the hyponeuston, makes them unusually vulnerable to sea surface warming. Fishing pressures on some populations are a potential added stressor that may increase vulnerability, although significant population declines have not been reported and are not suspected at present.

Life History Synopsis**:**

Yellowstripe goatfish (*Mulloidichthys flavolineatus*) occur throughout 13 Spalding et al. [2] biogeographic provinces in a variety of shallow-water habitats of the tropical and subtropical Indo-Pacific waters, between 30° N–37° S and 22° E–124° W, from South and East Africa to southern Japan, south-eastern Australia, Lord Howe Island, Micronesia, the Hawaiian Islands, and the Pitcairn Islands [3]. The Red Sea populations have been described as a separate subspecies, *M. f. flavicaudus,* by Fernandez-Silva and Randall (2016) [4,5]. This demersal species occurs at or near reefs that have an abundance of coral cover but is found more specifically at adjacent rubble and sediment habitats. It is found from less than 1 m to 97 m, but it usually occurs at depths of less than 20 m [3]. During the day, yellowfin goatfish form aggregations. Aggregations in shallow inlets and channels are comprised of 20 to more than 100 individuals, and many individuals may rest on the bottom. Aggregations in deeper waters can consist of more than 1,000 individuals extending more than 5 m above the bottom [3,6,7]. Adults have high site fidelity. They forage on sand-flats at night and return to their sheltering habitat by dawn. For three fish tracked in an Oʻahu Marine Life Conservation District, the mean nighttime and daytime ranges were 8,267 m^2 (range 5,200–11,600 m^2) and 2,533 m^2 (range 1,200–3,200 m^2), respectively [6]. Juveniles are common in shallow sandy areas during late summer.

Juveniles (less than 12 cm total length [TL]), young adults (between 12 and 17 cm TL), and adults (greater than 17 cm TL) had similar diets, particularly juveniles and young adults. According to stomach contents analyses, as small benthic juvenile yellowstripe goatfish grow, they prey on a wider variety of animals, including polychaetes, tanaids, and harpacticoid copepods [8,9]. They shift from a pelagic to a macrobenthic diet at the adult stage [8,10]. Adults are considered to be specialist benthic predators, foraging mainly on sediment-dwelling invertebrates around reefs. Polychaetes (macrofauna) contribute to the diet, perhaps due to selective feeding. At Kona, Hawaiʽi, bivalves, polychaetes, and amphipods were the most important prey [11]. At Midway Atoll, polychaetes were the most abundant prey item in their diet. Xanthid crabs, bivalves, gammaridean amphipods, and the tanaid *Leptochelia dubia* were also important components in this species' diet [12]. In contrast to other studies, fish were the dominant prey item at the Marshall Islands [13]. Yellowstripe goatfish feed most actively at dawn, dusk, and night, although they can also feed during daylight hours.

Count of pre-settlement otolith rings indicate that the pelagic larval duration is 45–60 days [14-16]. Goatfish transform from larvae to juveniles at a much smaller size than that at settlement, with scales and fins formed at ca. 13 mm SL [17]. The silvery-blue juveniles do not settle until 5-10 cm SL. This may make pelagic larval duration an inappropriate measure of dispersal ability. Kamikawa et al. [18] found that estimates of PLD for yellowstripe goatfish in Hawaiʽi could not be obtained from daily growth rings of specimens; this is probably related to the prolonged pre-settlement life of the pelagic juveniles after transformation from the larval stage. The silvery juveniles recruit to settlement habitats in large schools [19]. Kamikawa et al. [18] found that newly settled yellowstripe goatfish were caught almost exclusively on soft substrates in contrast to the hard substrates where yellowfin goatfish recruits were caught.

Yellowstripe goatfish are gonochoristic. Spawning aggregations have not been observed, although the tendency for this species to form resting aggregations suggests that they may be possible. Early work recorded spawning in the Mariana Islands almost year round, except for October and November, with the peak in March–April [19]. However, Reed and Taylor [20] found a clear spawning season there during May–June with a second peak in November. Peak spawning has been reported at other locations in summer (June, July, and August) [21]. Reed and Taylor [20] found that spawning occurred at 28 °C–29.5 °C in the Marianas and suggested that there are temperature thresholds for successful spawning. In Palau, spawning takes place over sandy areas near reef edges for several days following the new moon [22]. Reed and Taylor [20] also found evidence of lunar periodicity in spawning. Estimates of mean size at reproductive maturity are 18 cm fork length (FL) [23] and 16 cm TL from Saudi Arabia [19]. In the Mariana Islands, 50% maturity was found to occur at 15.8 cm FL for females and 16.1 cm FL for males [20]. The smallest mature individuals reported were 12.3 cm SL for males and 11.2 cm SL for females [19]. Maturity is thought to occur by age 1 [24]. Yellowstripe goatfish have pelagic eggs and larvae. Mullids in general have small eggs, 0.63–0.93 mm diameter, and hatch at 1.6–3.4 mm NL [17]. The larvae and pelagic juveniles of Mullidae are found almost exclusively in the upper few meters of the water column, often in the hyponeuston where they can be abundant in surface slicks (B Mundy, personal observation) [25,26]. Water temperature and photoperiod may cue settlement for yellowstripe goatfish, as they do for other reef fish in Hawaiʽi [27].

There are fisheries for the yellowstripe goatfish in much of its range [18,20]; however, significant population declines have not been reported and are not suspected [19]. They are caught using cast nets and gillnets, seines, traps, hooks and lines, and spears [28]. Settlement-stage juveniles are taken by hook-and-line, seine, and cast nets when they recruit to nearshore areas [29]. They are used directly as food or often used bait for larger fishes [18,20,28]. There is a daily bag limit of 50 juvenile goatfishes in

Hawaiʻi[1]. Adults are marketed fresh, and their flesh is considered a delicacy in some countries. There is a minimum size limit of 7 inches for adults in the Hawaiian Islands, except for Maui where the minimum size limit is 8 inches[2]. There is only a moderate amount of life history information for this species and no estimates for the intrinsic rate of increase r have been reported. The von Bertalanffy K is estimated as 0.564, the maximum age as 5 to 12 years, and the maximum size as 43 cm TL [18-20]. The growth equation is estimated as cm FL = $34.2^{(1-e-0.564(t \text{ in days}-0.564))}$ [9]. Natural mortality in Hawaiʻi was estimated as 0.46 [6,24]. Reed and Taylor [20] estimated total mortality in the Mariana Islands to be 1.14 year^{-1} (95% CI, 0.89–1.39), natural mortality as 0.64, and fishing mortality as 0.50 year^{-1}. The spawning potential ratio (SPR) in Hawaiʻi is estimated as 0.49 [24]. A recent assessment of the stock in Hawaiʻi reported that the population abundance overall appeared constant in recent years [24]. There is a catch limit of 50 fish per day for juvenile yellowfin goatfishes in Hawaiʻi [18]. Some populations occur in marine protected areas. The IUCN lists this species as of Least Concern for its conservation status [19].

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Yellowfin goatfish - *Mulloidichthys vanicolensis*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 89% of scores ≥ 2

	Mulloidichthys vanicolensis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.7	2.4	
	Prey Specificity	1.4	2.4	
	Adult Mobility	2.5	2.6	
	Dispersal of Early Life Stages	1.8	2.3	
	Early Life History Survival and Settlement Requirements	2.4	1.4	
	Complexity in Reproductive Strategy	2	1.4	
	Spawning Cycle	1.7	2.1	
	Sensitivity to Temperature	1.2	2.6	
	Sensitivity to Ocean Acidification	1.8	2.2	
	Population Growth Rate	1.3	2.2	
	Stock Size/Status	1.8	1.8	
	Other Stressors	2.4	2.2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1.1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Yellowfin Goatfish (*Mulloidichthys vanicolensis*)

Overall Climate Vulnerability Rank: **[Moderate].** (90% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.5) and Early Life History and Settlement Requirements (2.4).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution. The limited early life stage dispersal seems questionable, given the occurrence of this species across the Eastern Pacific biogeographic barrier and the genetic connectivity between populations throughout this species' range (Lessios and Robertson, 2013)[1].

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Yellowfin goatfish are associated with and may be dependent upon coral reefs, which are a biogenic habitat vulnerable to ocean warming and acidification. The prey of yellowfin goatfish includes species with a calcium carbonate shell, which are major but not irreplaceable components of the diet. Pollution and coastal development threaten the habitat of yellowfin goatfish in some areas. The occurrence of larvae and pelagic juveniles of goatfishes almost exclusively in the upper few meters of the water column, often in the hyponeuston, makes them unusually vulnerable to sea surface warming. Habitat displacement of yellowfin goatfish in Hawaiʽi by an introduced snapper may increase the susceptibility of the goatfish to predation. Fishing pressures on some populations are a potential added stressor that may increase vulnerability, although significant population declines have not been reported and are not suspected at present.

Life History Synopsis**:**

Yellowfin goatfish (*Mulloidichthys vanicolensis*) are found in 21 Spalding et al. [2] provinces. The species has an Indo-Pacific distribution between 32° N–34° S, 31° E–109° W from the Red Sea and South Africa through Indonesia and the Philippines, north to southern Japan and south to Lord Howe Island, eastward to the Hawaiian, Marquesan, and Tuamotu Islands. They are also known from the offshore islands of the tropical eastern Pacific and, perhaps as waifs, at the coast of the Americas, although their eastern Pacific sister species *M. dentatus* is much more common there [1]. Their depth range is 1 to 132 m [3,4]. Yellowfin goatfish are common throughout most of their range and are the most abundant goatfish in many areas. NOAA surveys recorded densities of this species as 28.1/ha in the main Hawaiian Islands, 20.3/ha in the Northwestern Hawaiian Islands, 5.0/ha in the southern Mariana Islands, 5.5/ha in the Northern Mariana Islands, 13.0/ha in the Line and Phoenix Islands, 1.4/ha at Wake Island, and 9.7/ha in American Samoa (NOAA unpublished data).

Habitat requirements were not reported separately for juveniles of this species. They inhabit reefs and sandy bottoms of reef flats, lagoons, coastal and seaward reefs, generally in deeper waters than

Mulloidichthys flavolineatus [4-6]. They have also been recorded in seagrass beds. Schumacher and Parrish [6] found yellowfin goatfish to occur primarily over reefs or at the reef/sediment interface. Yellowfin goatfish are demersal, living and feeding near the bottom as well as in the water to at least 5 m above the bottom, but usually within 2 m of the substrate [6]. They form large, inactive aggregations by day in coral reefs, dispersing to sand flats to feed at night [4,5,7] and returning to the same sheltering habitat by first light. Other *Mulloidichthys* species maintain home ranges under 1 km [8,9]. *M. vanicolensis* sometimes mix with bluestripe snapper, *Lutjanus kasmira,* and exhibit blue stripes. *Mulloidichthys* species have high site fidelity; they forage on sand-flats at night and return to the same sheltering habitat by first light. Other *Mulloidichthys* species maintain home ranges under 1 km [8,9]. Dietary requirements were not reported separately for juveniles and adults of this species. Yellowfin goatfish are benthic carnivores and consume small crabs, shrimps, and other crustaceans, small molluscs, polychaetes, and other worms, ostracods, ophiuroids, heart urchins, and foraminifera [4,5,10].

Mulloidichthys species have a pelagic spawning mode [11]. Mullids in general have small eggs, 0.63-0.93 mm diameter, and hatch at 1.6–3.4 mm NL [11] and a pelagic larval duration of 31–50 days; the one available estimate for the PLD of yellowfin goatfish is 36.3 days [12]. Goatfish transform from larvae to juveniles at a much smaller size than that at settlement, with scales and fins formed at ca. 13 mm SL [11]. The silvery-blue juveniles do not settle until 5–10 cm SL. This may make pelagic larval duration an inappropriate measure of dispersal ability. Kamikawa et al. [13] found that estimates of PLD for yellowfin goatfish in Hawaiʽi could not be obtained from daily growth rings of specimens; this is probably related to the prolonged pre-settlement life of the pelagic juveniles after transformation from the larval stage. The silvery juveniles recruit to settlement habitats in large schools [4].The larvae and pelagic juveniles of Mullidae are found almost exclusively in the upper few meters of the water column, often in the hyponeuston where they can be abundant in surface slicks (B Mundy, personal observation) [14,15]. Water temperature and photoperiod may cue settlement for yellowfin goatfish, as for other reef fish in Hawaiʽi [16]. Kamikawa et al. [13] found that newly settled yellowfin goatfish were caught almost exclusively on hard substrates, in contrast to the soft substrates where yellowline goatfish recruits were caught.

Yellowfin goatfish are gonochoristic*.* Spawning aggregations have not been observed, although the tendency for this species to form resting aggregations suggests that they may be possible. At Aqaba in the Red Sea, this species spawns between June and August [17]. The Hawaiian Islands population spawns almost year-round but with the lowest fecundity in November–January [18].

There are fisheries for the yellowfin goatfish in much of their range [13]; however, significant population declines have not been reported and are not suspected [3,4]. They are caught using cast nets and gillnets, seines, traps, hooks and lines, and spears [19]. Settlement-stage juveniles are taken by hook-and-line, seine, and cast nets when they recruit to nearshore areas [5]. These are used directly as food or are often used as bait for larger fishes [13,19]. There is a daily bag limit of 50 juvenile goatfishes in Hawaiʽi[3]. Adults are marketed fresh, and their flesh is considered a delicacy in some countries. There is a minimum size limit of 7 inches for adults in the Hawaiian Islands, except for Maui where the minimum size limit is 8 inches[4].There is only a moderate amount of life history information for this species and no estimates for the intrinsic rate of increase (r) have been reported. The von Bertalanffy K is estimated as 1.3, the size at maturity as 16.5–24 cm SL, the maximum size as 38 cm TL, and the maximum age as 5

[3] https://dlnr.hawaii.gov/dar/fishing/fishing-regulations/marine-fishes-and-vertebrates/
[4] https://dlnr.hawaii.gov/dar/fishing/fishing-regulations/marine-fishes-and-vertebrates/

years [3,4,18,20]. In the Hawaiian Islands population, size at 50% maturity was estimated as 17.5 cm FL for females, with 100% mature by 20 cm FL [18]. Natural mortality in Hawaiʻi is estimated as 0.61 [3]. The spawning potential ratio in Hawaii was estimated as 0.55.

This species is fished in many parts of its range, including Hawaiʻi [21]. Current population trends are regarded as stable, significant declines from fishing are not suspected at this time (e.g., Nadon [3] for the population in Hawaiʻi). It occurs in many Indo-Pacific marine protected areas. In Hawaiʻi, habitat displacement of yellowfin goatfish by the introduced blueline snapper, *Lutjanus kasmira,* may increase the susceptibility of the goatfish to predation [6]. There are no other known major threats to this species. Although there are no species-specific conservation measures in place for yellowfin goatfish, the IUCN lists this species as of Least Concern for its conservation status [4].

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Blotcheye soldierfish - *Myripristis berndti*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 75% of scores ≥ 2

	Myripristis berndti	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.4	2.6	
	Prey Specificity	1.6	2.4	
	Adult Mobility	2.7	2.6	
	Dispersal of Early Life Stages	1.6	2.6	
	Early Life History Survival and Settlement Requirements	2.1	1.4	
	Complexity in Reproductive Strategy	1.6	1.2	
	Spawning Cycle	2	1.4	
	Sensitivity to Temperature	1.4	2.8	
	Sensitivity to Ocean Acidification	1.8	1.8	
	Population Growth Rate	2.4	1.6	
	Stock Size/Status	1.4	1.8	
	Other Stressors	1.8	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.3	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Blotcheye Soldierfish (*Myripristis berndti*)

<u>Overall Climate Vulnerability Rank</u>: **[Moderate].** (75% certainty from bootstrap analysis).

<u>Climate Exposure</u>: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

<u>Biological Sensitivity</u>: **[Moderate]**. No sensitivity attributes scored above 3.0. Adult Mobility scored the highest at 2.7.

<u>Distributional Vulnerability Rank</u>: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization.

<u>Data Quality</u>: 75% of the data quality scores were 2 or greater.

<u>Climate Effects on Abundance and Distribution</u>:

Few studies examined the effect of climate factors on the population productivity or distribution of blotcheye soldierfish. This is a coral reef-associated species and, therefore, may face habitat degradation as the oceans warm and become more acidic [1].

<u>Life History Synopsis</u>**:**

This species occurs in the Indo-Pacific and Eastern Pacific: from East Africa south to Natal, South Africa, and east to the Clipperton, Cocos, and Galapagos islands, north to the Ryukyu Islands, and south to the Great Barrier Reef, Norfolk Island, and Lord Howe Island [2]. Blotcheye soldierfish occur throughout Micronesia and are common throughout Oceania and absent only from Easter Island [2]. They are associated with coral reefs and seagrass areas, which are vulnerable biogenic habitats [3]. Temperature likely effects spawning periodicity for reef fish around Hawaii, peaking in early summer, then decreasing with higher water temperatures in late summer [4]. This species may be reliant on eddies around Hawaiʻi to retain larvae near settling grounds [4-7]. Eggs and larvae can be retained by eddies formed off the coast or transported by currents, depending on the season and the oceanography. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km and cross- channel dispersal can be common [8]. It is possible that water temperature and/or photoperiod cues for settlement for reef fish around Hawaiʻi. Also, although not reported specifically for this species, coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [4,9]. This species is considered to be an outer reef specialist and may be limited to shelter areas; it is benthopelagic, reef-associated, and inhabits caves. The fish hide under ledges of subtidal reef flats, channels, margins, and outer reef slopes during the day and feed over reef flats, channels, and margins at night. They occur in loose aggregations [10-15] and feed mainly on plankton such as crab larvae [16,17]. In Hawaiʻi, their spawning potential ratio is 0.59 and population abundance has been relatively stable [18]. These fish are widespread and common throughout large parts of their distribution. Blotcheye soldierfish are listed as Least Concern by the IUCN [19].

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Pinecone soldierfish - *Myripristis murdjan*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 82% of scores ≥ 2

	Myripristis murdjan	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.1	2.4	
	Prey Specificity	1.4	2.4	
	Adult Mobility	2.8	2	
	Dispersal of Early Life Stages	1.9	2.2	
	Early Life History Survival and Settlement Requirements	2.3	1.2	
	Complexity in Reproductive Strategy	1.6	1.6	
	Spawning Cycle	2.2	1	
	Sensitivity to Temperature	1.5	2.6	
	Sensitivity to Ocean Acidification	2.2	2	
	Population Growth Rate	1.2	2	
	Stock Size/Status	1.4	1.8	
	Other Stressors	2.1	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Pinecone Soldierfish (*Myripristis murdjan*)

Overall Climate Vulnerability Rank: **[Moderate].** (84% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.8) and Early Life History and Settlement Requirements (2.3).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 82% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Pinecone soldierfish are widespread throughout the Indo-Pacific from the Galapagos Islands to the East African coast, and from the Ryukyu Islands of Japan south to New South Wales Australia [1,2]. The species is common in reef flats and shallow lagoon habitats, hovering near caves and overhangs, with a depth distribution down to about 50 m [3]. Like other members of the family Holocentridae, they are dependent upon heterogeneous structures such as corals, and the potential loss of that habitat through climate change [4,5] could impact distribution and abundance. Alternatively, the tropicalization of temperate marine ecosystems may extend coral reef habitat [6] and possibly that of the pinecone soldierfish, although the species' reliance on reef flat and shallow lagoon habitats may make it more directly vulnerable to increased ambient temperature [7]. Pinecone soldierfish have pelagic larvae [8] and may, therefore, be impacted by changes in sea surface temperature and current patterns [9] as well as ocean acidification which is predicted to have adverse impacts on the sensory abilities of pelagic reef fish larvae [10].

Life History Synopsis**:**

Pinecone soldierfish emerge nocturnally to feed primarily on a wide variety of planktonic crustaceans [2]. They attain a maximum length of about 25 cm fork length (FL) [11], and the maximum length recorded for this species from the Northern Mariana Islands was 22.3 cm FL [12]. The oviparous pinecone soldierfish are gonochoristic with external fertilization, dispersing unguarded eggs in open water over substrate [13]. The spawning period and behavior of the pinecone soldierfish have not been described, and although the pelagic larval duration (PLD) has not been determined, the PLD of the congeneric *Myripristis berndti* has been estimated at about 55 days [14]. Irisson et al. [15] reported that Holocentridae larvae, though found higher in the water column compared to other reef fish families, displayed a downward ontogenetic shift with larval development. Age and growth, size at maturity, and other life history parameters have not been formally estimated for the pinecone soldierfish.

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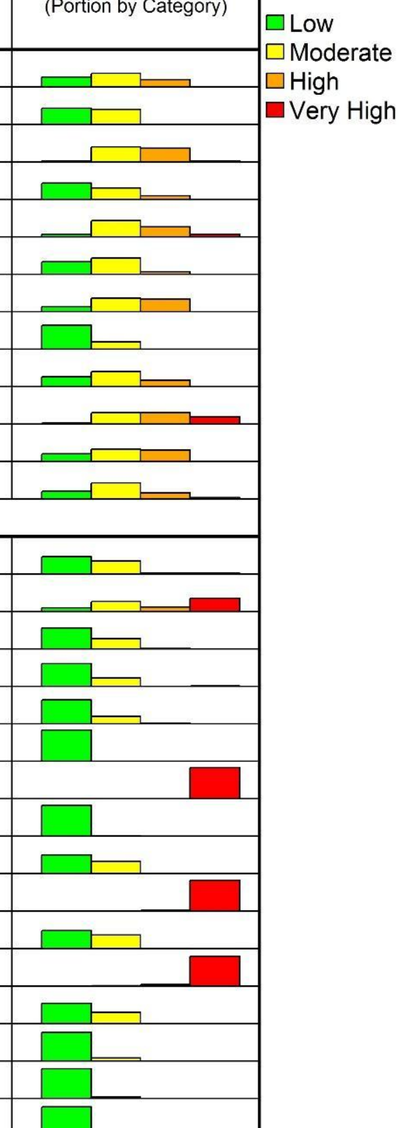
Sleek unicornfish - *Naso hexacanthus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 86% of scores ≥ 2

	Naso hexacanthus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.9	2.8	
	Prey Specificity	1.5	2.8	
	Adult Mobility	2.5	2.6	
	Dispersal of Early Life Stages	1.6	2.2	
	Early Life History Survival and Settlement Requirements	2.4	0.8	
	Complexity in Reproductive Strategy	1.7	1.4	
	Spawning Cycle	2.2	1	
	Sensitivity to Temperature	1.2	3	
	Sensitivity to Ocean Acidification	1.9	2	
	Population Growth Rate	2.8	2.2	
	Stock Size/Status	2.1	2.4	
	Other Stressors	2	1.6	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		



Sleek Unicornfish (*Naso hexacanthus*)

<u>Overall Climate Vulnerability Rank</u>: **[Moderate].** (58% certainty from bootstrap analysis).

<u>Climate Exposure</u>: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0),and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

<u>Biological Sensitivity</u>: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.5) and Population Growth Rate (2.8).

<u>Distributional Vulnerability Rank</u>: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

<u>Data Quality</u>: 86% of the data quality scores were 2 or greater.

<u>Climate Effects on Abundance and Distribution</u>:

Few studies examined the effect of climate factors on the population productivity or distribution of the sleek unicornfish. However, approximately 80% of surgeonfishes occurring exclusively in coral reef habitat are experiencing a greater than 30% loss of coral reef area across their distributions [1,2].

<u>Life History Synopsis</u>**:**

Naso hexacanthus are found from the Red Sea and East Africa including the Mascarene Islands to the Hawaiian, Marquesan, and Ducie Islands, northwards to southern Japan and southwards to Lord Howe Island. In the eastern Pacific, they are found from Clipperton Island and Cocos Island. *N. hexacanthus* occur at depths ranging from 6 to 229 m [1,3,4]. Juveniles are more common in mid-shelf reefs. Maximum age was estimated to be 44 years [5]. In the Great Barrier Reef, they have been reported to form spawning aggregations [6]. They may be reliant on eddies around Hawaii to retain larvae near settling grounds [7-10]. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km, and cross-channel dispersal can be common [11]. Though not reported specifically for this species, coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [12]. *N. hexacanthus* are common in deeper waters especially near escarpments and do not frequently occur in depths less than about 15 m [1,13]. This species is herbivorous up to 2 years of age. Juveniles feed on macroscopic and turf algae. *N. hexacanthus* consume larger zooplankton such as crab larvae, arrow worms, and pelagic tunicates [1,13]. This species is not highly mobile; their home range size is under 5 km^2 [14]. *N. hexacanthus* form large aggregations [1] and are common and locally abundant in parts of their range. While this species is enjoyed as a food fish and frequntly found in markets, there is no indication of declinging populations due to fishing. Additionally, they inhabit marine protected areas in certain parts of their range. They are listed as Least Concern by the IUCN. Spawning potential ratio for this species in the main Hawaiian Islands was 23% [15]. Habitat preference varies among surgeonfishes. Some inhabit coral reefs and others inhabit seagrass beds, mangroves, algal beds, and/or rocky reefs.

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Bluespine unicornfish - *Naso unicornis*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 89% of scores ≥ 2

	Naso unicornis	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.8	3	
	Prey Specificity	1.2	2.8	
	Adult Mobility	2.4	3	
	Dispersal of Early Life Stages	1.4	2	
	Early Life History Survival and Settlement Requirements	2.2	1.2	
	Complexity in Reproductive Strategy	1.9	2.4	
	Spawning Cycle	2.6	3	
	Sensitivity to Temperature	1.2	2.6	
	Sensitivity to Ocean Acidification	1.8	1.8	
	Population Growth Rate	3	2.2	
	Stock Size/Status	2.8	2.1	
	Other Stressors	1.8	1.6	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.3	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1.1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Bluespine Unicornfish (*Naso unicornis*)

Overall Climate Vulnerability Rank: **[High].** (96% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. One sensitivity attribute, Population Growth Rate, scored a 3.0. The next highest scores were for Spawning Cycle (2.6) and Stock Size/Status (2.8).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There has been no explicit study of the impacts of climate change on this species' distribution. Bluespine unicornfish area locally-abundant and widely-dispersed tropical and sub-tropical species, capable of utilizing multiple habitats [1]. They favor consumption of macroalgae that tends to be more abundant in sub-tropical habitats [2], which may be one reason why they are believed to have extended their range into some temperate areas. This was assumed to be a consequence of ocean warming [3].

Life History Synopsis**:**

Bluespine unicornfish are herbivorous "browsers" that target large, fleshy macroalgae, and have frequently been reported to be the dominant grazer of common macroalgal species in various locations [4-9]. This species is benthopelagic, reef-associated, occurs over coral and rock, and inhabits inshore areas but has been observed at depths of up to 120 m [10]. They are most abundant in shallower water [11]. Individuals of this species in Hawaii have been aged to at least 50 years in Hawaiʻi [12], but maximum age appears to be lower in other regions, e.g., to around 30 in Pohnpei, Guam, and Micronesia [13]. This species reaches sexual maturity at around 2–5 years old [12,13].

Home range sizes are highly variable, but potentially large, e.g., to 27 hectares [14-16]. They can also make crepuscular migrations of several hundred meters between daytime foraging areas and nighttime refuge holes [16]. Spawning is highly seasonal in Hawaiʻi, with a peak spawning period from May to June [17]. In Micronesia, spawning periods span several months and perhaps throughout the year [13].

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Arceye hawkfish - *Paracirrhites arcatus*

Overall Vulnerability Rank = Very High

Biological Sensitivity = High
Climate Exposure = Very High
Data Quality = 79% of scores ≥ 2

	Paracirrhites arcatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	3.3	3	
	Prey Specificity	1.5	2.6	
	Adult Mobility	3.3	3	
	Dispersal of Early Life Stages	2	2.2	
	Early Life History Survival and Settlement Requirements	2.3	1.2	
	Complexity in Reproductive Strategy	1.9	1.8	
	Spawning Cycle	1.9	1	
	Sensitivity to Temperature	1.6	2.8	
	Sensitivity to Ocean Acidification	2.2	2	
	Population Growth Rate	1.9	1	
	Stock Size/Status	1.2	1.8	
	Other Stressors	2.3	1.8	
	Sensitivity Score	High		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Very High		

Low
Moderate
High
Very High

Arceye Hawkfish (*Paracirrhites arcatus*)

Overall Climate Vulnerability Rank: **[Very High].** (99% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[High]**. Two sensitivity attributes scored above 3.0: Habitat Specificity (3.3) and Adult Mobility (3.3).

Distributional Vulnerability Rank: **[Low].** No attributes indicated higher vulnerability to distribution shift.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of arceye hawkfish. They are closely associated with live and branching coral, which is vulnerable to coral bleaching and ocean acidification [1-2].

Life History Synopsis**:**

Paracirrhites arcatus are distributed from East Africa through the Indo-Pacific, north to Japan, east through the East Indian region to the Hawaiian and Pitcairn Islands, and south to Australia (Great Barrier Reef and Western Australia), depth ranging predominantly from 1 to 35 m but as deep as 91 m [2-4]. *P. arcatus* are solitary. They inhabit coastal lagoons and seaward reefs and are associated with small branching corals, *Pocillopora*, *Stylophora*, and *Acropora* coral heads [2-5]. Temperature likely effects spawning periodicity for reef fish around Hawaii, peaking in early summer, then decreasing with higher water temperatures in late summer [6]. Spawning aggregations are not reported for this species. They may be reliant on eddies around Hawaiʻi to retain larvae near settling grounds [6-9]. Eggs and larvae can be retained by eddies formed off the coast or transported by currents, depending on the season and the oceanography. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations. A recent model of passive pelagic particle connectivity in the MHI found that when pelagic larval duration was set at 45 days, the median distance for successful settlers was around 100 km, and cross-channel dispersal can be common [6-10]. It is possible that water temperature and/or photoperiod cue settlement for reef fish around Hawaiʻi. Also, although not reported specifically for this species, coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [6,11]. They prey on shrimps, small fishes, crabs, and other crustaceans [2,12]. *P. arcatus* have a wide range and are abundant. They are collected as aquarium fish, but the aquarium trade is not a major threat. *P. arcatus* are found in numerous marine protected areas and are listed as Least Concern by the IUCN [2].

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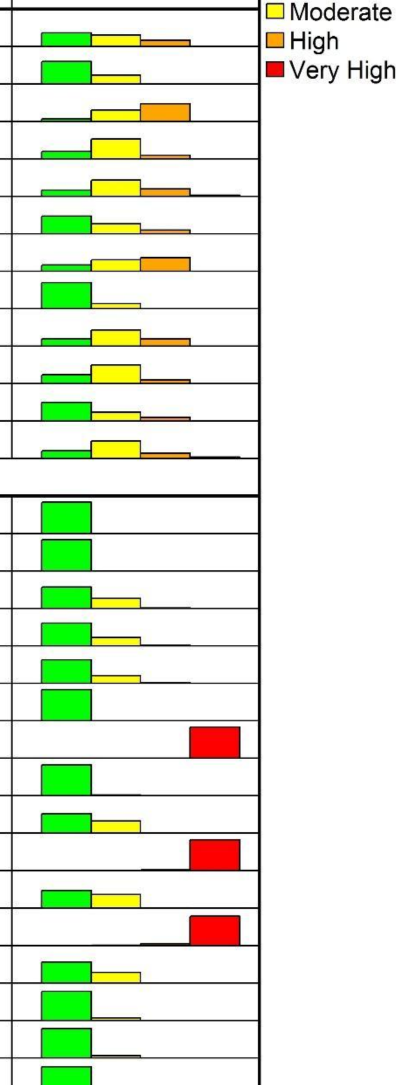
Dash-and-dot goatfish - *Parupeneus barberinus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 86% of scores ≥ 2

	Parupeneus barberinus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.8	2.8	
	Prey Specificity	1.3	2.8	
	Adult Mobility	2.5	2.4	
	Dispersal of Early Life Stages	1.9	2.2	
	Early Life History Survival and Settlement Requirements	2.1	1.2	
	Complexity in Reproductive Strategy	1.6	1.4	
	Spawning Cycle	2.2	2.5	
	Sensitivity to Temperature	1.2	3	
	Sensitivity to Ocean Acidification	2	2.2	
	Population Growth Rate	1.8	1.4	
	Stock Size/Status	1.5	2	
	Other Stressors	2	1.6	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.3	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		



Dash-and-dot Goatfish (*Parupeneus barberinus*)

Overall Climate Vulnerability Rank: **[Moderate].** (98% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.5) and Early Life History and Settlement Requirements (2.1).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 86% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Few studies examined the effect of climate factors on the population productivity or distribution of the dash-and-dot goatfish. This species utilizes multiple habitats and undergoes ontogenetic habitat shifts from mangroves/seagrasses to coral reefs—both of which are vulnerable to climate change impacts [1-2].

Life History Synopsis**:**

Parupeneus barberinus are found from East Africa to Micronesia and the Tuamotu Archipelago, and Australia (Queensland, New South Wales, and Western Australia) to Japan in depths ranging from 1 to 100 m [2,3]. They are associated with coral reefs and seagrass areas, which are vulnerable biogenic habitats [4]. In the Gulf of Aqaba, spawning season ranges from May to June [3,5]. They have a pelagic spawning mode, and eggs and larvae can be retained by eddies formed off the coast, or transported by currents, depending on the season and the oceanography. In general, self-recruitment has been reported for a range of coral reef species and in a variety of locations. Though not reported specifically for this species, coral (rather than algal dominated reefs) may be a cue for settlement through ambient sound and/or olfactory cues [6]. Juveniles typically occur in small, mixed-species groups in sparse seagrass habitats. Small fishes forage on the reef flat and slope and in the upper 2 cm of sediment. In contrast, larger fishes foraged on the reef edge and base at depths of 10 cm [3,7,8]. This species can occur on sand-rubble bottoms near reefs. Their habitat changes from mangroves/seagrasses to coral reefs as they experience an ontogenetic habitat shift [1,2]. In a field observational foraging study, fishes less than 120 mm TL (total length) consumed small ostracods and nematodes, fishes greater than 120 mm TL fed on bivalves, and fishes over 240 mm TL fed on bivalves and crabs [8]. They also consume sand-dwelling invertebrates such as polychaete worms, crustaceans, sipunculids, pelecypods, small gastropods, isopods, brachiopods. Feeding is diurnal [2,8-10]. Other *Parupeneus* species maintain home ranges less than 1 km [11]. This species is one of the most abundant species of *Parupeneus*. NOAA surveys around the Hawaiian Islands or Northern Mariana Islands did not observe *P. barberinus*. They were observed at Timor Leste (5.2/ha), Line and Phoenix Islands (1.7/ha), Wake Island (7.1/ha), and American Samoa (1.85/ha) (NOAA unpublished data) [2,12].

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Whitesaddle goatfish - *Parupeneus porphyreus*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate

Climate Exposure = Very High

Data Quality = 89% of scores ≥ 2

	Parupeneus porphyreus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.1	2.6	
	Prey Specificity	1.4	2.6	
	Adult Mobility	2.6	2.6	
	Dispersal of Early Life Stages	1.7	2.1	
	Early Life History Survival and Settlement Requirements	1.9	1.2	
	Complexity in Reproductive Strategy	1.7	1.6	
	Spawning Cycle	1.5	2.4	
	Sensitivity to Temperature	2.5	2.8	
	Sensitivity to Ocean Acidification	2	2	
	Population Growth Rate	1.2	2.1	
	Stock Size/Status	3	2.2	
	Other Stressors	1.7	1.8	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1	3	
	Current NS	1	3	
	Current Speed	1	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1	3	
	Surface Oxygen	4	3	
	Surface Salinity	1	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Whitesaddle Goatfish (*Parupeneus porphyreus*)

Overall Climate Vulnerability Rank: **[High].** (66% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. One sensitivity attribute scored 3.0, and that was Stock Size/Status. The next highest scores were for Adult Mobility (2.6) and Sensitivity to Temperature (2.5).

Distributional Vulnerability Rank: **[Moderate].** All four attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, relatively high habitat specialization, and sensitivity to temperature.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Whitesaddle goatfish are associated with and may be dependent upon coral reefs, which are a biogenic habitat vulnerable to ocean warming and acidification [1]. Pollution and coastal development threaten the habitat of the whitesaddle goatfish in areas where its range overlaps with human populations [2]. The occurrence of larvae and pelagic juveniles of goatfishes almost exclusively in the upper few meters of the water column, often in the hyponeuston, makes them unusually vulnerable to sea surface warming. Fishing pressure on populations in the main Hawaiian Islands is a major population stressor that increases vulnerability [3-5].

Life History Synopsis**:**

Whitesaddle goatfish (*Parupeneus porphyreus*) occur in only one Spalding et al. [6] biogeographic province. It is a reef-associated species endemic to the Hawaiian Archipelago and Johnston Atoll [7]. This species is found in lagoons and seaward reefs at 2–140 m [7]. Small groups of whitesaddle goatfish occur under ledges or among corals during daylight hours and feed among rocks and corals at night. It is most typically found low in the water column, less than 2 m from the bottom [8]. Adults shelter in holes in the reef during day and forage over sand and rubble at night, returning to the same hole in the morning [5,9]. Habitat requirements have not been reported separately for juveniles of this species. Whitesaddle goatfish are not highly mobile, but they do move between sheltering and feeding habitats [10]. Five fish tracked with acoustic tags at Coconut Island (Oahu) had home ranges from 9,070–35,163 m^2 [9]. This species exhibits site fidelity like other *Parupeneus* species [9].

Adults of this species feed nocturnally and at dawn or dusk on benthic crustaceans; juveniles feed during the day [11]. Six of 11 specimens speared during the afternoon in Kona, Hawaii, were empty or contained only trace amounts of well-digested prey. Five specimens speared within one hour of sunrise had full stomachs. Xanthid crabs accounted for 65.2% of volume followed by hippid crabs (10%) and caridean shrimps (2%) [12]. For fish larger than 110 mm, crabs were most important, followed by isopods, *Stenopus hispidus*, and alpheid shrimps [10]. Whitesaddle goatfish under 60 mm feed mostly on copepods, gammarids, megalops larvae, and caprellids [10]. The major prey items have exoskeletons of chitin instead of calcium-carbonate shells.

The pelagic larval duration for whitesaddle goatfish is 41–56 days (mean = 47.4) [13]. Whitesaddle goatfish transform from larvae to juveniles at a much smaller size than that at settlement, with scales and fins formed at ca. 13 mm SL [14]. The silvery-blue juveniles do not settle until 31–37 mm SL [10]. This may make pelagic larval duration an inappropriate measure of dispersal ability. There is no early life history specifically for the whitesaddle goatfish. Mullids in general have small eggs, 0.63–0.93 mm diameter, and hatch at 1.6–3.4 mm NL [14]. The larvae and pelagic juveniles of Mullidae are found almost exclusively in the upper few meters of the water column, often in the hyponeuston where they can be abundant in surface slicks (B Mundy, personal observation) [15,16]. Water temperature and photoperiod may cue settlement for whitesaddle goatfish, as for other reef fish in Hawaiʽi [17].

Whitesaddle goatfish are gonochoristic [11]. Spawning aggregations have not been observed. Spawning appears to be year-round, peaking from December to July; females may spawn more than once a year [10,13]. Cole [18] reported spawning only in January through March during 2008. Recruitment begins in March with no new settlers visible after June [10,13,19]. Size at first maturation is estimated as 23.6 cm FL [11], but the smallest mature female found was 26 cm TL [13].

Whitesaddle goatfish are valued food fish in the Hawaiian Islands, as they were even prior to European contact. This reef species sells for the highest price per pound in Hawaiʽi [11]. Populations are under fishing pressure that is directly related to the size of the human population in the different islands [3,4]. There is a minimum size limit of 10 inches TL for whitesaddle goatfish in the Hawaiian Islands, except on Maui where the minimum size limit is 12 inches; there is also a daily bag limit of one on Maui[5]. There is only a moderate amount of life history information for this species. The intrinsic rate of increase (r) has not been reported for this species. The von Bertalanffy K is estimated as 0.538, the maximum recorded size is 47 cm SL (51 cm TL) and the maximum age as 6 years [3,11,13]. The growth equation is estimated as $FL_t = 492(1\text{-}e^{-0.538\ yr\ (t+0.446)})$ [11]. Natural mortality was estimated as 0.53 [3]. The spawning potential ratio for whitesaddle goatfish in Hawaiʽi is 0.15. Some areas have experienced localized depletion. There is a correlation between human population and fish size, a proxy for fishing mortality. While recreational and commercial landings are variable, there has been a 33% decline in catch per unit effort of two fisheries (gill net and spear) over 10 years in the main Hawaiian Islands [5]. Depletion is most likely attributed to overexploitation [3-5]. This is a coral reef-associated species and may face habitat degradation as the oceans warm and become more acidic. Although about two-thirds of its distribution overlaps with marine protected and managed areas, this is primarily in the northern part of its range, where its densities are naturally low. The IUCN lists it as Near Threatened because its population decline is less than, but approaching, the 30% threshold for listing as Vulnerable [5].

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Sabre squirrelfish - *Sargocentron spiniferum*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 68% of scores ≥ 2

	Sargocentron spiniferum	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.4	2.6	
	Prey Specificity	1.9	1.8	
	Adult Mobility	2.7	1.6	
	Dispersal of Early Life Stages	2.3	1.6	
	Early Life History Survival and Settlement Requirements	2.4	1.2	
	Complexity in Reproductive Strategy	1.8	1.4	
	Spawning Cycle	2.2	0.4	
	Sensitivity to Temperature	1.3	2.2	
	Sensitivity to Ocean Acidification	2.2	2.2	
	Population Growth Rate	1.3	1.2	
	Stock Size/Status	1.9	1.2	
	Other Stressors	1.8	1.2	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.3	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.5	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1.1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Sabre Squirrelfish (*Sargocentron spiniferum*)

Overall Climate Vulnerability Rank: **[Moderate].** (53% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.4), Adult Mobility (2.7), and Early Life History and Settlement Requirements (2.4).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 68% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Sabre squirrelfish are widespread throughout the tropical and subtropical Indo-Pacific from the Red Sea and east African coast to the Pitcairn Islands, and from the Ryukyu Islands of Japan south to Australia [1]. They are typically solitary, with a depth distribution down to 122 m [2]. Similar to other members of the family Holocentridae, they are dependent upon heterogenic structures such as corals [3], and Lecchini et al. [4] experimentally found that sabre squirrelfish larvae positively responded to water from reefs dominated by coral as opposed to those dominated by algae. The potential loss of that habitat due to climate change [5,6] could therefore impact the distribution and abundance of the species. Alternatively, the tropicalization of temperate marine ecosystems may extend coral reef habitat [7] and possibly that of the sabre squirrelfish. They are broadcast spawners with a pelagic larval stage of unknown duration. Irisson et al. [8] found Holocentridae larvae higher in the water column in comparison to other reef fish families, though displayed a downward ontogenetic shift with larval development. Alterations of current patterns and sea surface temperatures due to climate change may impact connectivity in fish populations [9] and thus impact larval dispersal and subsequent abundances of Holocentridae. Ocean acidification will negatively affect the sensory abilities of pelagic larval reef fish, which will impact the ability of larvae to spatially orient, locate settlement habitat, and adjust vertical distribution, resulting in predicted declines in the recruitment of demersal reef fish species [10].

Life History Synopsis**:**

Sabre squirrelfish inhabit overhangs and crevasses of heterogeneous structures during the day, emerging at twilight to feed nocturnally on a wide variety of benthic invertebrates such as crabs and other crustaceans, shrimps, mollusks, polychaete worms, and fish [11]. Sabre squirrelfish attain a maximum length of about 45 cm FL [12], and the maximum length recorded for this species from the Northern Mariana Islands was 42.6 cm FL [13]. Age and growth, size at maturity, and other life history parameters have not been formally estimated for sabre squirrelfish. Values of natural mortality, growth (k), and maximum age have been reported by Weijerman et al. [14] for the congeneric bluelined squirrelfish (*S. caudimaculatum*) at 1.32, 0.73, and 3.9 years, respectively, and the silverspot squirrelfish (*S. tiere*) at 1.04, 0.57, and 5 years, respectively. Sabre squirrelfish attain an estimated maximum length greater than the two noted congenerics and can therefore be expected to exhibit lower natural mortality, lower growth rate, and greater maximum age. Spawning behavior and peak reproductive period for sabre squirrelfish have not been determined.

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Blue-barred parrotfish - *Scarus ghobban*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low

Climate Exposure = Very High

Data Quality = 79% of scores ≥ 2

	Scarus ghobban	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	1.7	2.8	
	Prey Specificity	1.4	2.8	
	Adult Mobility	2.2	2.4	
	Dispersal of Early Life Stages	1.8	2.2	
	Early Life History Survival and Settlement Requirements	2	1.5	
	Complexity in Reproductive Strategy	1.7	1.9	
	Spawning Cycle	1.6	1.6	
	Sensitivity to Temperature	1.2	2.8	
	Sensitivity to Ocean Acidification	1.7	2	
	Population Growth Rate	1.6	1.8	
	Stock Size/Status	2.5	1.9	
	Other Stressors	1.7	1.8	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.3	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Blue-barred Parrotfish (*Scarus ghobban*)

Overall Climate Vulnerability Rank: **[Moderate].** (100% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.2) and Stock Size/status (2.5).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization.

Data Quality: 79% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is little information available on climate effects on the blue-barred parrotfish abundance and distribution. Several studies have shown presence of parrotfish in ecosystems located at higher latitudes [1-4]. Averdlund [5] suggested that the first detection of these species beyond its known range can be used as a predictor of climate change impacts. It is possible that environmental changes due to CO_2-induced warming at higher latitudes allows some parrotfish to thrive in temperate areas, thereby altering the herbivory rates in new areas being colonized [6].

Life History Synopsis**:**

Blue-barred parrotfish are found in tropical waters in the eastern Mediterranean to the Pacific Islands. They also occur in the Red Sea, Oman, Persian Gulf, East Africa, South Africa, Madagascar, eastward to Cocos-Keeling, India, Sri Lanka, western Thailand, and southwest Indonesia [7-10]. Historical demographics of this species show that populations are genetically diverse and have a high gene flow [11].

Adult fish populations exhibit medium-scale movements (510–6,000 m) over soft bottoms between coral reef habitats separated by large areas of lagoon soft bottom [12]. In the western Indian Ocean, migration of this species corresponded with the flow of major oceanic and coastal currents in the region; self-recruitment has been recorded for a range of coral reef species and in a variety of locations [11,13]. Large adults form distinct pairings during spawning seasons but spawning aggregations have not been recorded [14].

This herbivorous, reef-associated species can be found at depths ranging from 3 to 36 m. Small groups of juveniles occur closer to shore on algae reef habitat or occasionally in silty, murky habitats [15,16]. The species may be dependent on the reef for shelter, especially during the juvenile stage [17,18]. It was observed that adult females preferred deeper habitats than males [17]. It was not reported for this species specifically; however, coral may be a cue for settlement through ambient sound and/or olfactory cues [19].

Blue-barred parrotfish are listed as Least Concern by the IUCN. The species is widespread and is relatively rare, though abundances increase in deeper waters [7,8]. The majority of parrotfish are found in mixed habitats (i.e., seagrass beds, mangroves, and rocky reefs). Approximately 78% of these mixed habitat species are experiencing greater than 30% loss of coral reef area and habitat quality across their distributions. More than 80% of species occuring exclusively in coral reef habitat are experiencing a greater than 30% of coral reef loss and degradation across their distributions [18,20].

Blue-barred parrotfish have a recorded maximum age of 6 years for females and 5 years for males in Micronesia [21]. The von Bertalanffy K parameter has been estimated to be 1.41 per year [21]. The maximum fork length length recorded in a Micronesia-based study on blue-barred parrotfish was 36.6 cm [21]. The fork length at sex change was estimated at 31.4 cm [21].

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Palenose parrotfish - *Scarus psittacus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low

Climate Exposure = Very High

Data Quality = 89% of scores ≥ 2

	Scarus psittacus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.1	2.6	
	Prey Specificity	1.5	2.4	
	Adult Mobility	2.7	2.2	
	Dispersal of Early Life Stages	1.8	2	
	Early Life History Survival and Settlement Requirements	2	1.4	
	Complexity in Reproductive Strategy	2	2	
	Spawning Cycle	1.6	2	
	Sensitivity to Temperature	1.7	2.6	
	Sensitivity to Ocean Acidification	1.6	2	
	Population Growth Rate	1.6	1.8	
	Stock Size/Status	1.7	2.2	
	Other Stressors	2.2	1.4	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.5	3	
	Bottom Temperature	2.8	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1.1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Palenose Parrotfish (*Scarus psittacus*)

Overall Climate Vulnerability Rank: **[Moderate].** (95% certainty in overall rank from bootstrap analysis.

Climate Exposure: **[Very High].** Three contributing climate exposure factors: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.7) and Other Stressors (2.2).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, temperature sensitivity was scored as [Low], which may reduce the likelihood of the species to shift distribution.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

There is little available information on the climate effects on the palenose parrotfish's abundance and distribution. Several studies showed presence of parrotfish in ecosystems located at higher latitudes [1-4]. Averdlund [5] suggested that the first detection of these species beyond their known range can be used as a predictor of climate change impacts. It is possible that environmental changes due to CO_2-induced warming at higher latitudes allows some parrotfish to thrive in temperate areas, thereby altering the herbivory rates in new areas being colonized [6].

Coastal development and pollution threaten over a quarter of all reef areas, while marine-based pollution and damage from ships threaten about 10% of reefs [7].

Life History Synopsis**:**

Palenose parrotfish are widespread in the Indo-Pacific and found from the Red Sea, Arabian Gulf, and Gulf of Aden to Sodwana Bay. Their range extends eastwards to Rapa and the Marquesas, northwards to southern Japan and southwards to Australia [8-10].

This species is abundant on reef fronts, in sheltered reef environments, and lagoons at depths ranging from 2 to 25 m [9]. During the day, juveniles and females can be found over shallow reef flats in aggregations while males are found solitary on the reef face. At night, these fish rest encased in a mucus envelope in reef crevices, indicating that they are likely limited to shertering areas [9,11,12]. Palenose parrotfishare not highly mobile. Though not reported specifically for this species, other parrotfish of similar size have a home range size of under 3 km up to 5 km for areas of use [13].

Palenose parrotfish are coral reef-associated fish that scrape benthic algae from rock surfaces during the day [14]. Degradation and loss of coral reef habitats threaten coral reef-associated species [15]. The majority of parrotfish are found in mixed habitats (i.e., seagrass beds, mangroves, and rocky reefs). Approximately 78% of these mixed habitat species are experiencing greater than 30% loss of coral reef area and habitat quality across their distributions. More than 80% of species occuring exclusively in coral reef habitat are experiencing a greater than 30% of coral reef loss and degradation across their distributions [8,16].

Palenose parrotfish have complex reproductive cycles in which they undergo a sex change from female to male (protogynous diandry/sequential hermaphrodites), but some individuals develop directly into males from their initial phase. Territorial phase male individuals exhibit territorial behavior and protect the groups of females in their home ranges [12,17-19]. They typically spawn from May through November. In Hawaiʻi, peak spawning season is August through November [17,20]. For other species of parrotfish, larger females may also produce more eggs in batches proportional to their size, spawn over a longer time frame, or spawn with a greater frequency [17,18].

Palenose parrotfish are widespread and both common and abundant in several parts of their home range. While they are caught in artisanal fisheries and heavily fished in some areas, such as Guam, they are not heavily fished in most of their range and can occur within marine protected areas. They are listed as Least Concern by the IUCN and have a spawning potential ratio of 0.41 in Hawaiʻi [8,21].

Palenose parrotfish have a maximum recorded age of 11 years, but population growth rates are not reported for this species [8,22]. The von Bertalanffy K-value was estimated to be 0.72/year [22]. Natural mortality was estimated to be 0.29/ year [21].

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Redlip parrotfish - *Scarus rubroviolaceus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low

Climate Exposure = Very High

Data Quality = 79% of scores ≥ 2

	Scarus rubroviolaceus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2	2.6	
	Prey Specificity	1.7	2.4	
	Adult Mobility	2.5	2	
	Dispersal of Early Life Stages	1.9	2.2	
	Early Life History Survival and Settlement Requirements	2.4	1.4	
	Complexity in Reproductive Strategy	2	2	
	Spawning Cycle	1.6	1.2	
	Sensitivity to Temperature	1.7	2.2	
	Sensitivity to Ocean Acidification	2	1.6	
	Population Growth Rate	2.1	1.8	
	Stock Size/Status	2.5	1	
	Other Stressors	2.2	1.4	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1.4	3	
	Bottom Temperature	3	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.4	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1.1	3	
	Wind NS	1	3	
	Wind Speed	1.1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		

Low
Moderate
High
Very High

Redlip Parrotfish (*Scarus rubroviolaceus*)

Overall Climate Vulnerability Rank: **[Moderate].** 61% certainty in overall rank from bootstrap analysis.

Climate Exposure: **[Very High].** Three contributing climate exposure factors: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.5), Early Life History and Settlement Requirements (2.4), and Stock Size/Status (2.4).

Distributional Vulnerability Rank: **[High].** Three attributes indicated high vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and habitat specialization. However, temperature sensitivity was scored as [Low], which may reduce the likelihood of the species to shift distribution.

Data Quality: 79% of the data quality scores were 2.0 or greater.

Climate Effects on Abundance and Distribution:

There are few studies that directly examine the effects of climate on the population productivity of redlip parrotfish. No current studies focus on physiological changes in parrotfish fecundity, sex change, or growth due climate change impacts that may contribute to abundance and distributional shifts. Several studies have shown the presence of parrotfish in higher-latitude ecosystems [1-4]. Averdlund [5] suggested that the first detection of this species beyond its known range can be used as a predictor of climate change impacts. It is possible that environmental changes due to CO_2-induced warming at higher latitudes allows some parrotfish to thrive in temperate areas, thereby altering the herbivory rates in new areas being colonized [6].

Life History Synopsis**:**

Redlip parrotfish are found in the tropical waters from the east coast of Africa to the Hawaiian and Line Islands to the eastern tropical Pacific. They occur in the U.S. waters of American Samoa, Guam, Northern Mariana Islands, Hawaiian Islands, Howland-Baker Island, Midway, and Wake Island [7]. Evidence strongly suggests that there is genetic break between Pacific and Indian Ocean populations, but there is no clear evidence of morphological differentiation [7].

Adult and large species of *Scarus* can form dense schools of 300–400 individuals, though they usually occur solitary or in pairs (G Allen, personal communication in [7]). They often inhabit non-reef rocky areas [8] and coral reefs [9]. Individuals have discrete home ranges and are site-attached; however, individuals can travel large distances (at least 400 m) from their home ranges. Home ranges are reported to be under 3 m and core areas of use less than 10 km for similar species in the same family.

Some parrotfish species inhabit coral reefs for most of their life stages and others occur in seagrass beds, mangroves, algal beds, and/or rocky reefs. The majority of parrotfish are found in mixed-habitat (primarily seagrass beds, mangroves, and rocky reefs). However, approximately 78% of these mixed-habitat species are undergoing a loss of habitat area and quality of greater than 30% across their distributions. More than 80% of species occuring exclusively in coral reef habitat are experiencing a greater than 30% of coral reef loss and degradation across their distributions. Corallivorous excavators are threatened by coral reef loss and worsening habitat quality; parrotfish species typically play major roles in reef dynamics and sedimentation [10]. Large-bodied parrotfishes, such as the redlip parrotfish, typically have higher biomass in wave-exposed and marine protected areas [11].

The current trend in global parrotfish abundance is unknown. Across the Pacific, abundance estimates suggest a density of 2–3 individuals per km^2. Redlip parrotfish were the most abundant large *Scarus* in the western Indian Ocean (Amirantes Seychelles) with estimates of 10–20 individuals per km^2 [7]. The stock status was estimated in Hawaii in 2017, with a spawning potential ratio of 0.26 [12].

Redlip parrotfish were deemed fast-growing and reach a maximum recorded age of 22 years in Hawaiʻi, 15 near Oman, 12 around the Great Barrier Reef, and 11 in the Seychelles [7]. The length at sexual maturity was estimated at 374 mm TL [13]. The von Bertalanffy K coefficient was estimated to be 0.28/year [14]. Natural mortality was estimated as 0.15/year [12]. The maximum length recorded in Hawaii was 508 mm [15]. The body length at median sexual maturity and median sex change were estimated at 350 mm and 473 mm, respectively [15].

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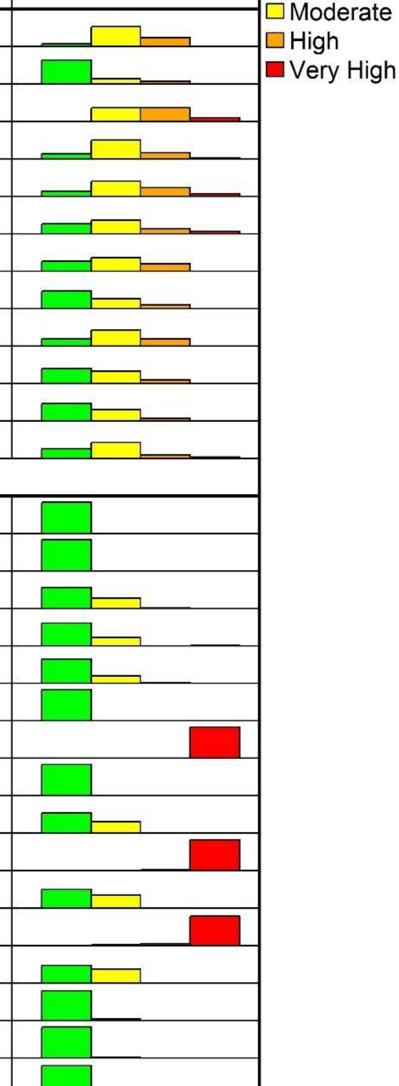
Goldspotted spinefoot - *Siganus punctatus*

Overall Vulnerability Rank = Moderate

Biological Sensitivity = Low
Climate Exposure = Very High
Data Quality = 71% of scores ≥ 2

	Siganus punctatus	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.2	2.8	
	Prey Specificity	1.3	2.4	
	Adult Mobility	2.7	2.2	
	Dispersal of Early Life Stages	2.1	1	
	Early Life History Survival and Settlement Requirements	2.3	0.6	
	Complexity in Reproductive Strategy	2	1.6	
	Spawning Cycle	1.9	1.6	
	Sensitivity to Temperature	1.6	2.6	
	Sensitivity to Ocean Acidification	2	1.8	
	Population Growth Rate	1.6	1	
	Stock Size/Status	1.5	1.2	
	Other Stressors	1.9	1.6	
	Sensitivity Score	Low		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		Moderate		



Goldspotted Spinefoot (*Siganus punctatus*)

Overall Climate Vulnerability Rank: **[Moderate].** (96% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Low]**. No sensitivity attributes scored above a 3.0. The highest scores were for Adult Mobility (2.7) and Early Life History and Settlement Requirements (2.3).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 71% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Goldspotted spinefoot (*Siganus punctatus*) are found in the western Pacific. They occur in Cocos-Keeling Islands east to Samoa and from Australia to southern Japan (30° N–25° S, 92° E–160° W) [1,2], and are found at depths up to 40 m [3]. Goldspotted spinefoot are rare in certain parts of their range. In the southern Mariana Islands region and Guam, there were an average of 0.1 and 0.4 individuals/hectare, respectively. In Timor Leste, there were 1.3 individuals/hectare. Their densities in Ifalik and Pohnpei were 0.5 individuals/hectare and 3 individuals/hectare, respectively. Goldspotted spinefoot were relatively abundant in Fiji and Raja Ampat (10.6 and 8.5 individuals/ha, respectively) [4,5].

Juveniles are found in shallow estuaries and form schools of approximately 50 individuals; schooling behavior decreases with size [2,4,6]. In contrast, adults live in clear lagoons and seaward reefs and are found in pairs after reaching 22 cm standard length (SL) [2,4]. Habitat for both these life stages, shallow estuaries and coral reefs, are vulnerable [4]. Goldspotted spinefoot are not highly mobile, with other *Siganus* species maintaining home ranges between 1 and 5 km [7].

Goldspotted spinefoot are listed as Least Concern by the IUCN. However, as a coral reef-associated species, they may experience habitat degradation as oceans warm and become more acidic [4,8]. Additionally, coastal development and watershed-based pollution threaten about 25% of reefs, while marine-based pollution and damage from ships threatens about 10% of reefs [9].

Life History Synopsis**:**

While spawning aggregations have not been reported, goldspotted spinefoot do spawn in pairs [4]. Spawning events occur around either new or full moons, or both. Seasonal periodicity was not reported [10]. Self-recruitment has been reported for coral reef species [7]. Information on reproduction and early life history has not been reported. Once reaching the juvenile stage, they are found in shallow estuaries and, eventually, coral reefs as adults [4]. Goldspotted spinefoot are herbivorous and feed on benthic algae [2].

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Little spine foot - *Siganus spinus*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate
Climate Exposure = Very High
Data Quality = 75% of scores ≥ 2

Siganus spinus		Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.6	2.4	
	Prey Specificity	1.2	2.4	
	Adult Mobility	2.4	2	
	Dispersal of Early Life Stages	1.9	2	
	Early Life History Survival and Settlement Requirements	2.3	0.8	
	Complexity in Reproductive Strategy	1.6	1.2	
	Spawning Cycle	2.1	0.8	
	Sensitivity to Temperature	1.3	2.4	
	Sensitivity to Ocean Acidification	1.8	1.8	
	Population Growth Rate	1.2	1.8	
	Stock Size/Status	2.6	1.4	
	Other Stressors	2	1.6	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1	3	
	Bottom Temperature	1	3	
	Current EW	1.3	3	
	Current NS	1.3	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.4	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Little Spine Foot (*Siganus spinus*)

Overall Climate Vulnerability Rank: **[High].** (73% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. No sensitivity attributes scored above a 3.0. The highest scores were for Habitat Specificity (2.6) and Stock Size/Status (2.6).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 75% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

Little spine foot (*Siganus spinus*) are found in the Indo-West Pacific from India and Sri Lanka to the Tuamotu Islands, north to Japan and south to New Caledonia (30° N–30° S, 77° E–129° W) [1,2]. They occur in 10 Spalding et al. [3] provinces, and their densities in the Southern Mariana Islands region, Guam, Fiji, and Raja Ampat were 0.4, 0.1, 38.6, and 9.2 individuals/ha, respectively [4,5].

Little spine foot occur in shallow coral reef flats and are found in small schools of fewer than 10 individuals [4]. They have been seen at depths up to 50 m [6]. They are not highly mobile and other *Siganus* species have home ranges between 1 and 5 km [7].

They are listed Least Concern by the IUCN [4]. As herbivores, little spine foot are not dependent on food sensitive to ocean acidification [4]. However, they do rely on coral reefs, a biogenic habitat vulnerable to ocean acidification and warming [4,8]. Additionally, coastal development and watershed-based pollution threaten about 25% of reefs, while marine-based pollution and damage from ships threaten about 10% of reefs [9].

Life History Synopsis**:**

No spawning aggregations or periodicity have been reported. Further information on spawning and early life history has not been reported. Generally, self-recruitment has been reported for coral reef species [7]. Little spine foot initially feed on fine textured algae and as adults, they consume coarser algae [4].

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Yellow tang - *Zebrasoma flavescens*

Overall Vulnerability Rank = High

Biological Sensitivity = Moderate
Climate Exposure = Very High
Data Quality = 89% of scores ≥ 2

	Zebrasoma flavescens	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Habitat Specificity	2.5	2.6	
	Prey Specificity	1.4	2.4	
	Adult Mobility	2.6	2.2	
	Dispersal of Early Life Stages	2.3	2.2	
	Early Life History Survival and Settlement Requirements	3.2	1.6	
	Complexity in Reproductive Strategy	1.7	2.6	
	Spawning Cycle	2	2.4	
	Sensitivity to Temperature	1.5	2.4	
	Sensitivity to Ocean Acidification	1.8	2.2	
	Population Growth Rate	2.5	1.9	
	Stock Size/Status	1.7	2.2	
	Other Stressors	2	1.4	
	Sensitivity Score	Moderate		
Exposure variables	Bottom Salinity	1.6	3	
	Bottom Temperature	2.5	3	
	Current EW	1.3	3	
	Current NS	1.2	3	
	Current Speed	1.2	3	
	Mixed Layer Depth	1.1	3	
	Ocean Acidification	4	3	
	Precipitation	1	3	
	Productivity	1.3	3	
	Sea Surface Temperature	4	3	
	Surface Chlorophyll	1.4	3	
	Surface Oxygen	4	3	
	Surface Salinity	1.5	3	
	Wind EW	1	3	
	Wind NS	1	3	
	Wind Speed	1	3	
	Exposure Score	Very High		
Overall Vulnerability Rank		High		

Low
Moderate
High
Very High

Yellow Tang (*Zebrasoma flavescens*)

Overall Climate Vulnerability Rank: **[High].** (94% certainty from bootstrap analysis).

Climate Exposure: **[Very High].** Three exposure factors contributed to this score: Ocean Acidification (4.0), Sea Surface Temperature (4.0), and Ocean Oxygen (4.0). Exposure to all three factors occurs during all life stages.

Biological Sensitivity: **[Moderate]**. One sensitivity attribute scored above a 3.0, and that was Early Life History and Settlement Requirements (3.2). The next highest score was for Adult Mobility (2.6).

Distributional Vulnerability Rank: **[Moderate].** Three attributes indicated moderate vulnerability to distribution shift: adult mobility, limited early life stage dispersal, and relatively high habitat specialization. However, sensitivity to temperature was scored as low which may mitigate the propensity of the species to shift distribution.

Data Quality: 89% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution:

No studies have explicitly tested the effects of climate factors on the abundance or distribution of *Zebrasoma flavescens*. However, *Z. flavescens* recruits and juveniles are highly associated with structurally-complex coral-rich habitat including finger coral beds which are key settlement habitats for this species [1,2]. Thus, to the extent that corals are threatened by climate change, there is potential for significant effects on key life stages.

Life History Synopsis**:**

Yellow tang are long-lived herbivorous species, with adults aged to at least 41 years [1]. Yellow tang settle into mid-depth (10 to 25 m) reef habitat with a high coral cover. On reaching sexual maturity (around age 4–7 years), individuals shift to spending daytime foraging in adjacent, shallow, complex habitats (reef flats and boulders) characterized by a high percentage of exposed rock covered by turf algae [2,3]. In west Hawaii, yellow tang migrate from daytime foraging habitat to deeper coral-rich areas to spawn at sunset along the edge of the outer reef slope [3,4]. Lunar periodicity is an inherent characteristic of reproduction; with peaks in mean daily egg production, female gonado-somatic index, and the fraction of females with eggs observed at full moons throughout the year [5]. A study in western Hawaii found that reproductive effort peaked in the late spring and summer and was lowest November to February, although some level of egg production continued throughout the year [5]. Yellow tang primarily feed on turf algae [6].

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